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Citation for published version (APA):

de Jong, J. R., Vangronsveld, K. L. H., Peters, M. L., Goossens, M. E. J. B., Onghena, P., Bulte, I., & Vlaeyen, J. W. S. (2008). Reduction of Pain-Related Fear and Disability in Post-Traumatic Neck Pain: A Replicated Single-Case Experimental Study of Exposure In Vivo. *The Journal of Pain*, 9(12), 1123-1134. <https://doi.org/10.1016/j.jpain.2008.06.015>

Document status and date:

Published: 01/01/2008

DOI:

[10.1016/j.jpain.2008.06.015](https://doi.org/10.1016/j.jpain.2008.06.015)

Document Version:

Publisher's PDF, also known as Version of record

Document license:

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Reduction of Pain-Related Fear and Disability in Post-Traumatic Neck Pain: A Replicated Single-Case Experimental Study of Exposure In Vivo

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Abstract: For patients with acute post-traumatic neck pain (PTNP), pain-related fear has been identified as a potential predictor of chronic disability. If such is the case, fear reduction should enhance the prevention of further pain disability and distress after traumatic neck pain disability. However, exposure-based treatments have not been tested in patients with PTNP. Using a replicated single-case crossover phase design with multiple measurements, this study examined whether the validity of a graded exposure in vivo, as compared with usual graded activity, extends to PTNP. Eight patients who reported substantial pain-related fear were included in the study. Daily changes in pain intensity, pain-related fear, pain catastrophizing, and activity goal achievement were assessed. Before and after each intervention, and at 6-month follow-up, standardized questionnaires of pain-related fear and pain disability were administered, and, to quantify daily physical activity level, patients carried an ambulatory activity monitor. The results showed decreasing levels of self-reported pain-related fear, pain intensity, disability, and improvements in physical activity level only when graded exposure in vivo was introduced, and not in the graded activity condition. The results are discussed in the context of the search for customized treatments for PTNP.

Perspective: This is the first study showing that the effects of graded exposure in vivo generalize to patients with chronic PTNP reporting elevated levels of pain-related fear. This could help clinicians to customize treatments for PTNP.

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Key words: Pain-related fear, graded exposure in vivo, graded activity, post-traumatic neck pain disability.

An increasing number of both experimental and clinical studies, mainly performed in patients with chronic low back pain (CLBP), have shown that pain-related fear is one of the most potent predictors of observable physical performance, self-reported disability levels in daily life situations, and work loss.^{11,26,33,80} The basic tenet of the fear-avoidance model of pain is that the

way in which pain is interpreted may lead to 2 different pathways. When dysfunctional beliefs about pain exist, a number of safety behaviors are initiated that may be adaptive in acute pain but paradoxically worsen the problem in the case of long-lasting pain. Typical safety behaviors are avoidance/escape behaviors and hypervigilance and the prolonged use of them maintains the fear level rather than reduces it. Fearful patients have a risk of getting mired in a downward cycle of pain, fear, avoidance, and increased disability. In contrast, when acute pain is perceived as less threatening, patients are likely to maintain their engagement in daily activities, through which functional recovery is promoted.^{5,80} The fear-avoidance model has been successfully tested in patients with back pain,^{51,70,71} osteoarthritis,²⁸ and burn injuries.⁶¹

Received November 8, 2007; Revised June 11, 2008; Accepted June 18, 2008.

Supported by grant No. 940-31-071 of the Netherlands Organisation for Health Research and Development (ZonMw).

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doi:10.1016/j.jpain.2008.06.015

If pain-related fear is indeed one of the important mechanisms responsible for the development and maintenance of chronic pain disability, fear reduction should enhance the prevention of further pain-disability and distress. Well-designed procedures exist for the treatment of specific fears and phobias and usually these involve repeated and systematic exposure to fear-provoking stimuli, often presented in the context of behavioral experiments.^{6,12,13} Although Philips⁵⁰ argued for the application of exposure techniques to chronic pain some time ago, the first systematic experimental studies and randomized, controlled clinical trials in patients with chronic back pain were carried out more recently.^{9,15,34,37,81-83,89}

In patients with post-traumatic neck pain (PTNP) pain-related fear is also found to be an important predictor for chronic disability.^{43,44} Given the beneficial effects of cognitive behavioral interventions for chronic pain,⁴² cognitive behavioral therapy programs have been developed for patients with PTNP disability as well,^{25,29,35,36,64,67} of which those promoting physical activity have proven to be the most effective.^{14,52,58,64,75,76} Although these studies suggest that activity increase is associated with faster return to work and a decrease in pain and disability levels, there is evidence showing that these changes are mediated by the reduction of the catastrophic (mis)interpretations of pain.^{38,62,65} Therefore, we decided to test the effectiveness of an intervention that has catastrophic interpretations and associated pain-related fear as its primary target. Given the beneficial results of graded exposure in vivo (GEXP) in patients with CLBP, and since pain-related fear has shown to be associated with neck pain injury,⁴³ there are good reasons to believe that an GEXP treatment would be beneficial for the PTNP population as well.

Using a replicated crossover, single-case, experimental phase design with multiple measurements, we examined whether the validity of a GEXP, as compared with a usual operant graded activity program (GA), extends to patients with chronic PTNP disability. We expected that GEXP would be superior to GA in patients reporting elevated levels of pain-related fear.

Materials and Methods

Study Design

A sequential replicated crossover, single-case, experimental phase design was used. This design contains both direct and systematic replication elements to examine the effectiveness of GEXP as compared with GA. Direct replication is replication of the same experiment with another patient. Patients were randomly assigned to 1 of the 2 conditions. Randomization occurred after the 14 baseline days (BAS) and was done by a computer system, providing allocations in a file that could be assessed only by an independent research administrator. In condition I, patients received GEXP first, followed by GA. In condition II, the sequence of treatment modules was reversed.

Participants

Eight consecutive patients who had chronic neck pain (>12 weeks) after a motor vehicle accident were included in the study. All patients were diagnosed as having whiplash-associated disorder (WAD), resulting from an acceleration-deceleration mechanism of energy transfer on the cervical spine. On the basis of these predetermined inclusion and exclusion criteria, the present study focused on patients with grades I (neck pain but no physical findings) and II (pain and musculoskeletal findings such as reduced cervical range of motion) as decreed by the grading system of the Quebec Task Force on WADs associated with motor vehicle collisions.⁶⁶ Patients with signs of a concussion, retrograde, or post-traumatic amnesia, serious injuries (eg, fractures, traumatic internal organic pathology), and any neurological signs were excluded. Two of the 8 participants reported memory problems, 3 reported problems concentrating, and 4 reported neither problems in memory or concentration. Besides the above-mentioned other exclusion criteria were illiteracy, pregnancy, alcohol or drug abuse, non-Dutch-speaking, and serious psychopathology. To check the latter, preset criteria based on Dutch norms were applied on the Symptom Checklist (SCL-90).³ Because of post-traumatic amnesia and non-Dutch-speaking, 2 potential participants were excluded from the study. With regard to psychopathology none of the potential participants were excluded. The sample consisted of 5 male and 3 female patients, with a mean age of 45 ± 10.30 (SD) years and a mean duration of pain disability of 44.4 months (range, 27.6–67.2 months). The patients were referred for outpatient behavioral rehabilitation at the department of rehabilitation of the Maastricht University Hospital or the Hoensbroek Rehabilitation Center and reported substantial fear of movement/(re)injury (Tampa Scale for Kinesophobia [TSK]³² score ≥ 40).

The Medical Ethics Committee of the Rehabilitation Foundation Limburg-Institute for Rehabilitation Research Hoensbroeck approved the research protocol in addition to the institutional committee of the University Hospital Maastricht.

Procedure and Program Overview

Patients were first evaluated by the rehabilitation physician, who conducted a full physical examination, evaluated previous diagnostic tests, and who informed participants about the study. When patients agreed to participate, the researcher sent additional written information, along with an informed consent form, TSK, and SCL-90. If patients scored ≥ 40 on the TSK and fulfilled the preset SCL-90 criteria, they were invited for an intake procedure.

During the intake procedure, information was gathered to complete a behavioral analysis of the pain problem with special attention to the patient's catastrophic interpretations of his/her pain problem. At the end of the interview, the therapist encouraged the patient to formulate specific treatment goals, preferably in terms of activities that had been avoided such as household

chores, leisure, or work activities. A hierarchy of fear-eliciting movements and activities was made using the Photograph series of Daily Activities for the upper extremities (PHODA),¹⁶ a standardized method during which patients are requested to judge the harmfulness of 125 diverse physical movements from daily life activities represented by photographs. Using a (fear) thermometer, each picture is given a rating between zero (representing the situation which is not harmful for the neck) to 100 (representing the situation that is absolutely damaging the neck). Various forms of PHODA have been used successfully in previous studies.^{15,34,81-83}

After this assessment, patients started with a no-treatment 2-week BAS. During the second week of BAS, patients wore ambulatory accelerometry-based activity monitors to register daily activity levels. After this first period, the 8 patients were randomly allocated to 1 of 2 intervention sequences, GEXP followed by GA or vice versa. GA consisted of 20 sessions of 1 hour during 10 weeks. GEXP consisted of 12 sessions of 1 hour during 6 weeks. After termination of GEXP and GA, patients carried the activity monitor for 1 week with the instruction to resume their daily activities as much as possible. The fourth period was a 6-month follow-up (follow-up) at the end of which patients once more carried the accelerometry-based activity monitor for 1 week. During BAS, GEXP, GA, and follow-up, patients completed daily measures at home. Questionnaires were completed before and after BAS, after GEXP, after GA, and at follow-up.

Interventions

Two different outpatient therapist teams provided GA and GEXP. Both teams consisted of a behavioral therapist and an occupational or physical therapist experienced in the cognitive-behavioral rehabilitation of patients with chronic pain. GEXP and GA are highly structured, protocolized, and individually tailored and aim to restore a normal pattern of daily function, including complete return to work. Pain reduction is not a direct goal of either intervention.

Graded Exposure In Vivo

The GEXP consists of several components: Goal identification, education, exposure in vivo, and generalization.

Goal Identification

First, the patient is invited to formulate his or her own treatment goals. The therapist makes clear that GEXP does not primarily aim at reducing pain but at the restoration of functional abilities despite pain. Subsequently, the patient and therapist agree on 1 or more realistic and specific goals that are formulated in positive terms. Activities (eg, lifting weights) that are in line with these goals (eg, return to work) are those that will be included in the graded exposure sessions.

Education

Patients are given a careful explanation of the fear-avoidance model,^{78,79} using their own individual symp-

oms, beliefs, and behaviors in relation to their pain complaints. The therapist illustrates the paradoxical and dysfunctional effects of avoidance as safety behavior and offers the patient a new view on pain as a common condition that can be self-managed rather than as a serious disease or a condition that needs careful protection. One of the major goals of the educational component is to help the patient understand that the consequences of pain are catastrophically overestimated.

Exposure In Vivo

Individually tailored practice tasks are developed based on the graded hierarchy of fear eliciting activities and/or movements. The exposure takes the form of a series of behavioral experiments in which dysfunctional beliefs are explicitly being challenged. These assumptions take the form of "If . . . , then . . ." statements (eg, "If I lift up my child, then nerves in the neck region will rupture and my muscles will get blocked") and are empirically tested during a behavioral experiment.

Generalization

To enhance generalization and maintenance exposure is provided to the full spectrum of contexts and natural settings in which fear has been experienced, and the stimuli are varied. For example, bicycling can be done on a city bike and/or mountain bike, uphill as well as downhill, on rough as well as even terrain, and so on. The exposure procedure included activities from PHODA and other activities. A more detailed description of GEXP can be found in Vlaeyen et al.^{84,85}

Graded Activity

The GA is based on the programs originally described by Fordyce²⁴ and updated by Sanders.⁵⁹ The main goal of GA is the systematic removal of the contingent relationship between overt pain behavior and its positive consequences. This implies that GA is guided by the patient's functional abilities and a time-contingent rather than a pain-contingent regimen. In this study, GA consisted of the following components: Education, identification of goals, establishment of a baseline, successive approximation, and generalization.

Education

The educational session is similar to the one in GEXP, except that the focus is on the detrimental effects of inactivity and not on dysfunctional beliefs.

Identification of Goals

Similar to GEXP, realistic and functional treatment goals are formulated based on the patient's main complaints. Goals are split up into separate activities in the quota system.

Establishing Baseline Levels

For each of these activities, a baseline level is determined based on a pain-contingent principle ("go on with this activity until your pain makes you feel like discon-

tinuing"). Afterward, time-contingent treatment quotas for each activity are developed, always starting below the mean baseline value.

Successive Approximation

During the treatment phase, the patient systematically increases the time-contingent quotas to enable him/her to reach his/her personal goals within the preset therapy time period. The patient practices at home and documents every activity or exercise on a performance chart. These charts are discussed in each treatment session, and all team members positively reinforce the individual progress and successive approximations towards pre-defined (sub)goals.

Generalization

At the end of the treatment, activities are planned outside the hospital, preferably in the home and work setting to enhance response generalization. A more detailed description of GA can be found in Sanders.⁵⁹

Outcome Measures

The primary outcome measures are self-reported achievement of functional goals, and pain disability. Secondary outcome measures are pain catastrophizing, pain-related fear, physical activity levels in the home situation, and pain intensity.

Daily Diary Measures

To check whether the GEXP and/or GA indeed modified activity goal achievement, pain-related fear, and pain intensity, a brief diary was used consisting of 14 items with visual analog scales (VAS). The first 11 items (Table 1) represented the main factors of existing questionnaires for fear of movement/(re)injury (TSK),^{27,32,57} fear of pain (Pain Anxiety Symptoms Scale; PASS),^{40,41} and pain catastrophizing (Pain Catastrophizing Scale; PCS).^{69,72} All items were scored on 10-cm VAS, anchored "totally disagree" to "totally agree." Three main scores were derived, consisting of the mean scores (range, 0–10) of the items from the TSK, PASS, and PCS. Pain intensity was measured with an additional VAS anchored with "no pain at all" at one extreme and "worst pain experienced" at the other. The last 2 VAS referred to the performance of personally relevant activities that represented 2 main functional goals. Each scale was preceded by the same question: "How difficult was it to perform this activity today?" The scale was anchored with "no problem at all" at one extreme and "impossible" at the other. The diary was completed during the whole duration of the study, and the follow-up period of 1 week. The patients were requested to complete the diary each evening and to send the package by mail to the researchers the next day. The diary has been shown to be sensitive to GEXP in previous studies.^{15,81-83}

Functional Disability

The Neck Disability Index (NDI) is a 10-item self-reporting instrument for the assessment of physical disability of

Table 1. Items of the Shortened and Adapted Versions of the TSK, PASS, and PCS That Are Completed on a Daily Basis

Fear of movement/(re)injury (adapted and modified from TSK)	
1.	If I exercise I might be in danger of reinjuring myself (Harm)
2.	My body is telling me I have something dangerously wrong (Fear)
3.	My pain complaints would decrease if I were to exercise (Exercise)
4.	I can't do everything because it's too easy for me to get injured (Avoidance)
Fear of pain (adapted and modified from PASS)	
1.	I become sweaty when in pain (Somatic anxiety)
2.	I feel confused when I hurt (Cognitive anxiety)
3.	When I feel pain, I think that something dreadful may happen (Fear)
4.	When I feel pain I try to stay as possible (Escape/Avoidance)
Pain catastrophizing (adapted and modified from PCS)	
1.	When I am in pain I keep thinking about how badly I want the pain to stop (Rumination)
2.	When I am in pain I wonder whether something serious may happen (Magnification)
3.	When I am in pain I feel I can't go on with my daily activities (Helplessness)

Abbreviations: PASS, Pain Anxiety Symptoms Scale; PCS, Pain Catastrophizing Scale; TSK, Tampa Scale for Kinesophobia.

subjects with neck pain, particularly from whiplash-type injuries.⁷⁷ Each item is scored from 0 to 5. The NDI has been shown to have a high degree of test-retest reliability, internal consistency, and acceptable level of validity being sensitive to severity levels and to changes in severity over time.^{56,77} Disability categories for the NDI are: 0 to 4 = no disability, 5 to 14 = mild disability, 15 to 24 = moderate disability, 25 to 34 = severe disability, and above 34 = complete disability. We used a Dutch version, which has shown to be a reliable and responsive instrument in patients with acute neck pain in general practice.^{30,86}

Pain-Related Fear

The complete Dutch version of the TSK was used. This questionnaire consists of 17 items, measuring fear of (re)injury due to movement, scored on a 4-point scale. The TSK has been found reliable and valid and was capable to predict chronic disability in neck pain.^{43,44}

Physical Activity Level

To objectively assess physical activity level (PAL) in the home situation of the patients, patients carried a CSA/MTI uniaxial accelerometry-based electronic activity monitor (Computer Science and Applications, now Manufacturing Technology Incorporated, Fort Walton Beach, FL). The monitor is attached to a belt dorsally, at the height of the thoracic vertebrae and uses a built-in single axis accelerometer designed to detect normal human motion. The monitor outputs movement counts, which reflect the summation of vertical accelerations from 0.05 to 2.1 G. Data was stored for 1 week. The subjects wore

the accelerometer during the daytime except during water-based activities. The data were downloaded to a computer via an infrared interface for data processing. Raw data were exported in 1-minute intervals and saved in separate files for each subject. Patients kept a notebook daily in which they registered the time carrying the activity monitor and the kind of activities performed. Total physical activity was expressed as total counts divided by registered time; counts · min⁻¹ · d⁻¹ (counts per minute of days registered). The activity monitor used in our study appeared to have acceptable reliability for most research applications.⁸⁸

Manipulation Check

To check whether the threat value of physical activities was diminished as a result of GEXP, the PHODA for upper extremities was repeated after baseline, GA, and GEXP. Each photograph is given a rating according to the position on the fear thermometer. A total score ranging from 0 to 100 is calculated as the sum of each rating, divided by 125 (the maximum total score).

Validity Checks

To avoid contamination the GEXP and the GA were given by different experienced therapists. In addition and to avoid contamination as a result of patient interactions, patients randomly assigned to the different conditions received their treatments at different days. Finally, records of activity performances, according to graded hierarchies or preset quota, were kept to enhance the compliance of the patients.

Statistical Analyses

Besides graphical interpretations for analyzing the data of the daily measures, a randomization test for single-case experimental phase designs, based on the random determination of the moments of phase change or intervention points, was carried out.^{17,18,22,45,47} With respect to Student *t* tests, analysis of variance *F* tests, or other inferential procedures from within the general linear model framework, randomization tests have the advantage of being valid for single-case experiments without making distributional assumptions,^{18,20,47} of being easy to apply,^{18,47} and of being extremely versatile for even the most complex single-case designs.^{46,48} A randomization test is a permutation test based on random assignment to test a null hypothesis about treatment effects in a randomized experiment.¹⁷⁻²⁰ The randomization tests for the different single-case designs all make use of a directional test statistic (a difference between means). Replicated single-case experiments may be considered as multiple studies that can be combined using meta-analytical procedures. In the current study we used *P* value combining, which has the advantages that it is broadly applicable and that it is distribution-free without converting the scores to ranks or signs.^{19,47} A more detailed description of the randomization tests for single-case experimental designs and sequential replication

designs in particular can be found in Onghena and Edgington.⁴⁷

Because GEXP was expected to be superior to BAS and GA, the null hypothesis that there is no differential effect for any of the measurement times was tested using a randomization test on the differences between GEXP and BAS, GA and BAS, and GA and GEXP. Although follow-up is expected to be superior to BAS and will not change in relation to GEXP, differences between follow-up and BAS, follow-up and GA, follow-up and GEXP were also tested using randomization tests. The analysis is performed using the SCRT software (Single-Case Randomization Tests, version 1.1; Katholieke Universiteit Leuven, Leuven, Belgium).⁴⁶ Finally, the test is repeated, assuming delayed effects until the minimal *P* value (*P* < .05) is reached.^{19,20,87} One effect lag equals 1 week, or 2 treatment sessions.

Preset Criteria for Nondaily Measures

For the nondaily measures, the limited number of data made it impossible to use randomization tests. Therefore, we decided to formulate preset criteria to conclude whether the treatment could be considered successful. For the NDI, a 5-point change is required to be clinically meaningful.⁶⁸ For the TSK and PHODA, we considered a 50% decrease would give enough support that the threat value of the activities had decreased. This decision was based on the results of exposure studies of patients with CLBP who show at least a comparable decrease for these variables.^{15,81-83}

Results

Manipulation Check

The results of the PHODA for upper extremities, used to check whether the threat value of physical activities has diminished as a result of GEXP, are summarized in Table 2. In condition I, as compared with the start of GEXP (PHODA score = 86), a relevant reduction (≥50% decrease) in PHODA-scores is observed at the end of GEXP (PHODA score = 9), and there was no further reduction during GA (PHODA score = 7) and follow-up (PHODA score = 8). In condition II, the PHODA score increased somewhat from 85 at the start of GA to 68 at the end of GA. However, once again, when GEXP was introduced, the PHODA score decreased further to 8 (≥50% decrease) and remained at this level. At the end of GEXP the PHODA score was decreased to 8, which remained at the same level at follow-up.

Daily Measures

Because the patterns of change for fear of movement/(re)injury, fear of pain, pain catastrophizing, and pain experience of each patient within both conditions are quite similar, we decided to calculate group means of the time series for these variables. This produced more conveniently arranged graphs. Fig 1 displays the graphical representations for fear of movement/(re)injury, pain experience, fear of pain, and pain catastrophizing. Visual

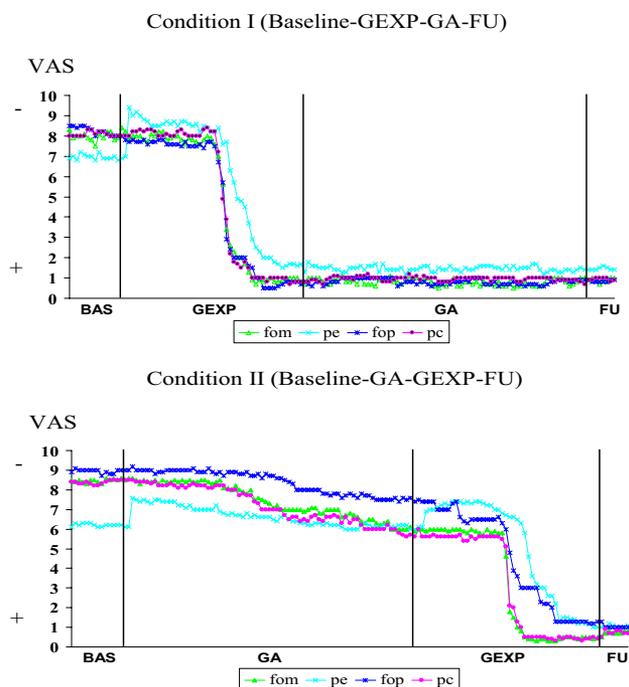


Figure 1. Means calculated from the time series of each patient within condition I ($n = 4$) and condition II ($n = 4$) for fear of movement/(re)injury (fom), pain experience (pe), fear of pain (fop), and pain catastrophizing (pc) as measured with the daily diary, across baseline (BAS), graded exposure in vivo (GEXP), graded activity (GA), and 6-month follow-up period (FU). BAS = 14 days, GEXP = 42 days (12 sessions of 1 hour) + 7 days of activity monitor; GA = 70 days (20 sessions of 1 hour) + 7 days of activity monitor, FU = 7 days. VAS, visual analog scale.

inspection reveals that in both conditions trend changes occur after the introduction of GEXP only and that these changes are still present during the 6-month follow-up period. By contrast, the introduction of GA does not lead to observable trend changes. These observations suggest that, for chronic neck pain patients who reported substantial pain-related fear, fear of movement/(re)injury, pain experience, fear of pain, and pain catastrophizing are reduced only by GEXP. It is also remarkable that at the onset of GEXP in both conditions pain experience increased. There appears to be an increase in pain experience at the start of the sessions before the standard decrease observed in sessions 7 through 9. In fact, in condition II, this increase in pain appears to return to levels that were experienced at the start of the GA protocol. Also, in both conditions, the results suggest that the decrease in pain experience temporarily follows an associated decrease in fear of movement/(re)injury.

The graphical representations of personally relevant activities for both conditions are displayed in Fig 2. Because both selected activities show the same patterns of change for each patient, only 1 activity per person is presented. Again, only substantial trend changes are observed when GEXP is introduced.

The results of the randomization tests on the raw data of the daily measures confirm the conclusions of the graphical display. For the variables fear of movement,

fear of pain and pain catastrophizing the moments of phase change or intervention points in which significance is reached take place during the GEXP (Table 3). Because the above-mentioned variables show the same results (P values) for each patient only the variable fear of movement is presented. For all patients in condition I (BAS-GEXP-GA-follow-up), the effect lag during GEXP, in which the minimum P values ($P > .05$) for the randomization tests was reached, is the fifth week. In condition II (BAS-GA-GEXP-follow-up), this is the same for patient 1 and 5. Conversely, for patient 6 and 8 the minimum P value was reached in the fourth week of GEXP. With regard to pain experience and the performance of personally relevant activities such as constructing a floor, gardening, mountain biking/jogging, working as a nurse/salesman, playing with the children, looking backward, and dancing, significant moments of phase change ($P > .05$) occurred only during GEXP, in both conditions in the fifth week (Table 3). For all variables, the measurement periods after the GEXP did not provide any other significant phase changes with regard to a positive improvement or a possible relapse.

Functional Disability

Functional disability assessed by the NDI is shown in Table 2. In both conditions at the start and the end of BAS the mean score equates with "completely disabled." Clinically meaningful changes (≥ 5 -point change) are observed when GA (mean score of 35.5–27) as well as GEXP

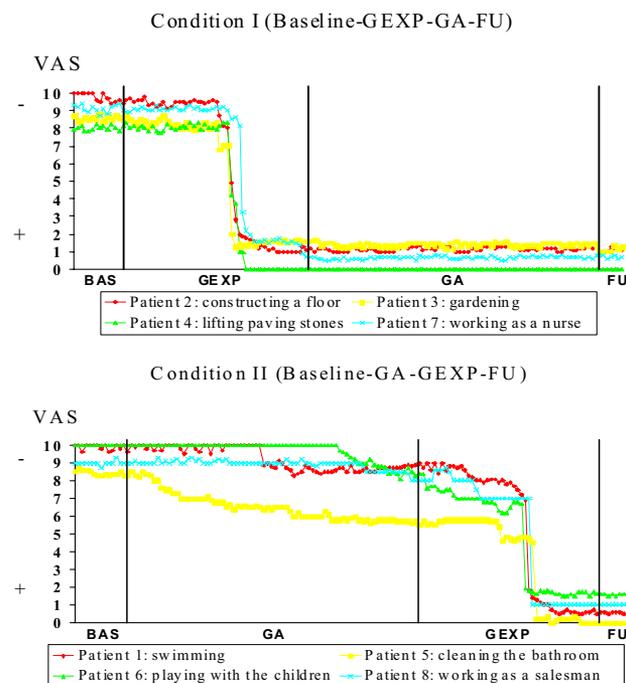


Figure 2. Mean daily measures for each patient in condition I and condition II for 1 of the 2 selected personally relevant activities, across baseline (BAS), graded exposure in vivo (GEXP), graded activity (GA), and 6-month follow-up period (FU). BAS = 14 days, GEXP = 42 days (12 sessions of 1 hour) + 7 days of activity monitor; GA = 70 days (20 sessions of 1 hour) + 7 days of activity monitor, FU = 7 days. VAS, visual analog scale.

Table 2. Mean Scores (Range) for Pain-Related Fear (TSK and PHODA) and Pain Disability (NDI), Determined at Baseline, Before, and After Each Treatment Module, and at the 6-Month Follow-Up for Condition I (n = 4) and Condition II (n = 4)

CONDITION INTERVAL	NDI (0–50)	TSK (17–68)	PHODA (0–100)
Condition I			
Baseline	37.8	47.5	83
Start GEXP	37.8	47.5	86
End GEXP	7.5	24	9
Start GA	7.5	24	9
End GA	7.5	24	7
6-mo follow-up	8.5	25	8
Condition II			
Baseline	35.5	48	85
Start GA	35.5	48	85
End GA	27	41	68
Start GEXP	27	41	69
End GEXP	8.5	23	8
6-mo follow-up	8.5	23	8

Abbreviations: TSK, Tampa Scale for Kinesophobia; PHODA, Photograph series of Daily Activities for the upper extremities; NDI, Neck Disability Index; GEXP, graded exposure in vivo; GA, graded activity.

(mean score of 37.8–7.5) is introduced first. However, considering the disability categories for the NDI, patients in condition II are still “severely disabled” at the end of GA, whereas the patients in condition I report mild disability at the end of GEXP. When GEXP follows GA in condition II, the mean score for the NDI decreased further (mean score of 27–8.5), which means that the GEXP provides for a situation in which patients are “mildly disabled.” The measurement periods after the GEXP did not show new clinical relevant changes in either category for functional disability.

Pain-Related Fear

Clinically relevant change for pain-related fear, defined by a minimum of 50% decrease on the mean TSK score, is only observed when GEXP is delivered (Table 2). In condition I the mean TSK score decreased from 47.5 at the start of GEXP to a mean TSK score of 24 at the end of GEXP. This clinically relevant reduction remains after GA and at follow-up. In condition II, there is a slight decrease at first of the mean TSK score from 48 to 41 as the result of GA and a clinically relevant change to 23 at the end of GEXP, which remains at follow-up.

Physical Activity

The physical activity data obtained by accelerometry are summarized in Table 4. Compared with BAS, in condition I a marked increase of physical activity, expressed as total movement counts per minute of days registered, is observed during GEXP (220 ± 8.75 to 574 ± 17.75). When GA followed BAS, as prescribed for condition II, physical activity was also increased (217 ± 7.98 to 356 ± 6.09) but to a lesser extent than in condition I in which GEXP followed BAS. In condition II, physical activity increased further when GEXP followed GA (356 ± 6.09 to 564 ± 23.30). In contrast, the degree of physical activity did not change appreciably when GA follows GEXP (condition I). Regarding physical activity during follow-up in condition I as compared with GA, a slight reduction is observed (578 ± 22.43 to 543 ± 12.69), whereas in condition II, the degree of physical activity remains almost the same as at the end of GEXP (564 ± 23.30 to 561 ± 22.91). However, in both conditions, physical activity at follow-up is much higher than at BAS.

Discussion

This is the first study showing that the effects of GEXP generalized to patients with chronic PTNP reporting el-

Table 3. The Effect Lag During the Graded Exposure In Vivo in Which the Minimum P Values for the Randomization Tests With 1 Observation Per Phase Has Been Reached for Each Patient in Condition I and Condition II for Fear of Movement, Pain Experience, and 2 Personally Relevant Activities

CONDITION INTERVAL	FEAR OF MOVEMENT	PAIN EXPERIENCE	ACTIVITY 1	ACTIVITY 2
Condition I				
Patient 2	5 ($P = .024$)	5 ($P = .029$)	5 ^a ($P = .024$)	5 ^b ($P = .024$)
Patient 3	5 ($P = .024$)	5 ($P = .024$)	5 ^c ($P = .024$)	5 ^d ($P = .024$)
Patient 4	5 ($P = .021$)	5 ($P = .024$)	5 ^e ($P = .021$)	5 ^f ($P = .021$)
Patient 7	5 ($P = .029$)	5 ($P = .037$)	5 ^g ($P = .029$)	5 ^h ($P = .029$)
Condition II				
Patient 1	5 ($P = .013$)	5 ($P = .013$)	5 ⁱ ($P = .013$)	5 ^j ($P = .016$)
Patient 5	5 ($P = .016$)	5 ($P = .024$)	5 ^k ($P = .016$)	5 ^l ($P = .016$)
Patient 6	4 ($P = .024$)	5 ($P = .024$)	5 ^m ($P = .024$)	5 ⁿ ($P = .024$)
Patient 8	4 ($P = .029$)	5 ($P = .037$)	5 ^o ($P = .029$)	5 ^p ($P = .024$)

NOTE. The effect lag (1 lag is 1 week or 2 sessions of exposure therapy) during the graded exposure in vivo in which the minimum P values for the randomization tests with 1 observation per phase has been reached for each patient in condition I (baseline – graded exposure in vivo – graded activity – 6-month follow-up) and condition II (baseline – graded activity – graded exposure in vivo – 6-month follow-up) for fear of movement, pain experience, and 2 personally relevant activities.

^aMountain bike; ^bconstruct a floor; ^cgarden; ^djogging; ^elift paving stones; ^fplay soccer; ^gride; ^hwork as nurse; ⁱswim; ^jlook back; ^kclean the bathroom; ^lcycle;

^mdance; ⁿhaving a romp with the children; ^odrive a car; ^pwork as salesman.

Table 4. Total Amount of Physical Activity, Adjusted for Time Wearing the Activity Monitor in Condition I and Condition II

CONDITION INTERVAL	TOTAL PHYSICAL ACTIVITY (COUNTS · MIN ⁻¹ · D ⁻¹)			
	MEAN	MINIMUM	MAXIMUM	SD
Condition I (n = 4)				
Baseline	220	208	232	8.75
GEXP	574	554	601	17.75
GA	578	548	611	22.43
6-mo follow-up	543	529	564	12.69
Condition II (n = 4)				
Baseline	217	210	229	7.98
GA	356	348	364	6.09
GEXP	564	545	602	23.30
6-mo follow-up	561	543	598	22.91

Abbreviations: GEXP, graded exposure in vivo; GA, graded activity.

NOTE. Total amount of physical activity (expressed as activity counts per minute of days registered; counts · min⁻¹ · d⁻¹) adjusted for time wearing the activity monitor in condition I (baseline – graded exposure in vivo – graded activity – 6-month follow-up) and condition II (baseline – graded activity – graded exposure in vivo – 6-month follow-up).

evated levels of pain-related fear. By using a replicated single-case, crossover, experimental phase design, the aim of this study was to examine the effectiveness of GEXP as compared with GA in reducing the threat value of physical activities and/or movements and to restore daily functioning in 8 patients with chronic PTNP reporting substantial fear of movement and/or (re)injury. The patients were referred for outpatient behavioral rehabilitation. Both the randomization tests on the daily measures and the pre- and post-treatment phase measures showed that compared with GA, GEXP was superior in decreasing levels of pain-related fear, pain catastrophizing, pain disability, and pain experience, both after treatment and at follow-up. However, it should be mentioned that the results of the nondaily measures, with limited number of data points, were not subjected to randomization tests and for the most part based on arbitrary preset criteria. Improvements were found not only in the self-report measures but also in physical activity in the home situation, as measured with ambulatory activity monitors. Because the experimental design did not include washout periods between the different treatment components, it is likely that carry-over effects occurred. Indeed, when GA followed GEXP, the improvements remained stable, which is also consistent with the favorable follow-up results.

As noted in the introduction, GA showed to be helpful for chronic neck pain disability across a number of studies. However, in the current study, change during GA was marginal at best when GA preceded GEXP. Both GA and GEXP were performed according to a specific protocol. In addition, a different therapist team gave GA and GEXP. Because patients' attitudes and beliefs, and thereby patients' disability levels, may be derived from the projected attitudes and beliefs of health care providers,⁵⁴ the 2 teams were comparable in terms of experience and therapists' prefer-

ences. Efforts were made to achieve the same level of enthusiasm in each therapist who participated in either GA or GEXP.

Besides the superiority of GEXP over GA, there is a sudden and remarkable level of improvement around sessions 7 to 9 during GEXP. The content of these sessions mainly consisted of exposure to personally relevant activities that represented the main functional goals that were chosen by the patients themselves. Research into return of fear and contextual renewal shows that the beneficial effects of exposure are more or less confined to the context in which the exposure treatment was performed.^{10,53,74} This means that confrontations with the (previously) fearful activity in other contexts could elicit a certain level of fear. However, the results in this study show that overall daily activity, as measured by the activity monitor, increased both in the short and long term. It seems likely that daily life activities not only consisted of situations that were part of GEXP.

GEXP has successfully been applied to patients with CLBP. Besides some single-case, experimental studies, randomized controlled clinical trials also have shown positive results recently with regard to pain disability and pain-related fear.^{9,15,34,37,81-83,89} However, in comparison with the single-case, experimental exposure studies in patients with low back pain,^{15,81-83} the current study shows that more exposure sessions are needed to demonstrate trend changes and significant effects in patients with PTNP. A possible explanation is that neck pain patients experience multiple complaints and fears, not just fear of movement. Besides neck pain, symptoms such as headache, visual disturbances, dizziness, weakness, paraesthesia, nausea, both upper and lower limb numbness and tingling, tinnitus, and cognitive problems (concentration and memory disturbances) are common in the acute stage after a traumatic event.^{7,21} In CLBP, patients' main concern is overall the experienced pain interfering with daily life activities. In addition, the concerns of the neck pain patients may be more difficult to challenge (eg "If I would lift heavy weights, then I do not have full control of my neck, which will worsen the pain complaints, with the result that I will not be able to do my job in the future").

It is of interest that current pain experience was also affected by GEXP. Moreover, the current results suggest that the decrease in pain experience temporarily follows an associated decrease in pain-related fear. Similar results are observed in the single-case, experimental studies of GEXP in CLBP^{15,81-83} and are in line with the fear-avoidance model. However, such strong reduction in pain is not common in usual cognitive-behavioral treatments for chronic pain.^{31,42} How can this unexpected result be explained? One explanation is that fear reduction is associated with a decrease in muscle activation,⁴⁴ which in turn may be associated with a reduction of pain experience.²³ By avoiding the use of painful muscles to prevent the amplification of pain and further injury, muscle activation is decreased. Alternatively, experimental studies on the role of attention and pain-related fear have shown that patients with elevated levels of pain-related fear habitually attend to somatic sensations.^{4,49} This finding

corroborates the idea that the most important function of anxiety is the early detection of potentially threatening situations. It is likely that the decrease in pain experience during GEXP was mediated by a process in which the reduction of the threat value of previously fear-eliciting stimuli also produced a redirection of the attention away from pain and bodily sensations. Finally, pain reduction might be the direct result of the diminished threat value of physical activities.² This is in line with recent imaging studies showing a relationship between catastrophizing and activity in cortical regions associated with affective, attention, and motor aspects of pain.⁶⁰

Despite the overall positive influence of GEXP on pain experience, there appears to be an increase in pain experience at the onset of GEXP. A possible explanation may have to do with the natural history of the participants. They could all be characterized as not-at-fault drivers. Research has shown that the not-at-fault driver is angry at someone else's actions.^{21,39} They interact with the other driver and others with a notion of that "stupid driver" injured them and keeping him/her from attaining an important goal.^{8,21} Besides, also subjectively aversive conditions which are the result of the injury can generate anger.⁸ An example of such aversive conditions could be exposure to activities and/or movements in which physical discomfort or pain will be experienced.^{1,8} The induction of anger, for his part, and also pain-evoked cardiac responses that are modulated by anger produces increased pain intensity and pain unpleasantness.⁵⁵

Finally, several limitations of the study should be mentioned. First, this study is limited in that it included only 8 patients. However, a replicated crossover, single-case, experimental design was chosen with a customized randomization test to perform statistical analyses, which is an added value to detect idiosyncratic functional relationships and behavioral laws. Second, because in the crossover design all patients received both GEXP and GA, long-term differential effects could not be established. Replication studies in the form of randomized, controlled trials using larger samples are warranted. However, single-case experiments have higher practicality as compared with randomized, controlled trials and therefore are more useful to demonstrate accountability in a clinical setting on a more regular basis.⁴⁸ In addition, the application of single-case experiments is an obvious option if the research interest is in the evaluation of individualized custom-made therapy.⁴⁷ Third, by definition, it is not possible within single case studies to assess generality across subjects. However, interventions that produce

dramatic effects are likely to generalize more than those with weaker effects, and this appears to be true in this study. Using randomization tests as time series analysis, we have demonstrated that the changes could not be attributed to chance. Besides, generalization may be derived from the fact that replications of eight different patients show consistently similar results in this study and in studies of patients with CLBP. So far, it seems justifiable to generalize the results to other patients with chronic PTNP who report substantial pain-related fear. However, it should be mentioned that patients who also report serious psychopathology did not participate in this study. Regarding limits of using GEXP to treat patients with fear or anxiety and significant psychopathology, the literature is not univocal. The same goes for the effect of psychopathology in cognitive-behavioral interventions as treatment for chronic pain. Therefore, it is quite possible that GEXP may also be a successful intervention for patients with PTNP who report serious psychopathology. In this study, the decision about excluding patients with serious psychopathology was based on criteria of earlier trials.^{31,63,73} Fourth, this study did not check whether pain behavior has decreased as a result of GA. Finally, the follow-up period may not have been sufficient to determine the long-term effect on the treatment or long-term disability.

In sum, the current study supports a GEXP approach in chronic PTNP patients reporting substantial levels of pain-related fear. The GEXP was successful in decreasing levels of self-reported pain-related fear, disability, pain experience, and increasing the level of daily life physical activity as measured with an accelerometry-based activity monitor. These results underscore the idea that GEXP modifies the meaning people attach to their neck pain complaints, and those changes also influence the experienced painfulness. The results need to be verified in a wider chronic PTNP population. However, providing patients who report pain-related fear with a structured exposure in vivo program seems a promising treatment direction.

Acknowledgments

The authors thank Marlies den Hollander, Christoph Loo, Corine Cuypers, Marianne Maas, and Joop Ruijgrok, of the Department of Occupational Therapy, Physiotherapy, and Rehabilitation, University Hospital Maastricht, The Netherlands, and Mario Geilen, Herman Mulder, Noël Dortu, and Peter Heuts, of Hoensbroek Rehabilitation Center, Heerlen, The Netherlands, for their therapeutic input during the study.

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