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Electronic diary assessment of pain, disability and psychological adaptation in patients differing in duration of pain

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Abstract

Computerized diary measurement of pain, disability and psychological adaptation was performed four times a day for 4 weeks in 80 patients with various duration of unexplained pain. Reported are (1) the temporal characteristics and stability of pain report during the 4-week measurement period, (2) the association between pain duration and pain report, disability and general psychopathology, and (3) the accordance between diary assessment versus questionnaire assessment of pain, disability and psychological adaptation. No evidence of instrument reactivity was found: pain report was stable across the 4-week period. However, pain report appeared to be highly variable both between and within days. About half the patients showed a clear increasing trend in pain during the day. Several differences were found between subgroups of patients varying in pain duration. Patients with less than 6 months of pain reported significantly less pain intensity, disability and fatigue than patients whose pain persisted for more than 6 months. Pain coping and responses to pain behaviors by the spouse also differed for the subgroups: longer pain duration was associated with increased catastrophizing and solicitous responses from the spouse. Comparison of scores obtained with diary versus questionnaire assessment indicated moderate correlations for most variables. Retrospective (questionnaire) assessment of pain intensity yielded significantly higher pain scores than diary assessment. © 2000 International Association for the Study of Pain. Published by Elsevier Science B.V.

Keywords: Chronic pain; Diary assessment; Pain intensity; Pain adjustment; Disability; Temporal characteristics

1. Introduction

A large number of studies of the chronic pain disorder (CPD) has been devoted to the identification of psychological factors, contributing to the maintenance of the pain or pertaining to physical, mental and social aspects of the disability resulting from the pain problem. Pain cognitions, pain coping factors and spouse responses to pain behavior have been indicated as important determinants. For the most part, conclusions are based on cross-sectional studies that rely on one to a few assessments of the relevant attribute. In addition, the association between a psychological factor and an increase of pain or disability has typically been established for groups of patients by means of correlational procedures. There have also been some studies relating psychological factors to variations in pain report and well-being in individual patients on the basis of repeated diary assessments (Linton and Gunnar-Gotestam, 1985; Affleck et al., 1992a,b, 1994, 1996; Geisser et al., 1995; Tennen and Affleck, 1996; Porter et al., 1998). However, these studies were confined to only a few variables, and a more comprehensive assessment within patients of psychological functioning in relation to pain intensity and disability is called for. We therefore employed intensive diary assessments of reported pain intensity and disability, and of pain cognitions, pain coping and spouse responses to pain behavior to study the associations between these variables as well as their temporal characteristics in patients varying in pain duration.

The pain taxonomy of the International Association for the Study of Pain (Merskey, 1986) includes standards for the temporal characteristics of pain: pain can be (1) continuous or nearly continuous – non-fluctuating; (2) continuous or nearly continuous – fluctuating; (3) recurring, irregularly; (4) recurring, regularly; (5) paroxysmal; or (6) sustained with superimposed paroxysms. How pain intensity actually fluctuates within days or across several days has not been

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studied much. In order to verify actual temporal pain characteristics diary assessments seems best suited, although a potential limitation of diary assessments is reactivity to the repetitiveness of the recording. Pain report may either increase due to sensitivity (Affleck et al., 1991; Cruise et al., 1996) or it may decrease due to response fatigue, which could both be induced by the daily measurement. The studies concerned with this issue measured pain once a day (Affleck et al., 1991; von Baeyer et al., 1994) for 7 days (von Baeyer et al., 1994; Cruise et al., 1996) or 2 weeks (Kerns et al., 1988) and produced no evidence for both types of reactivity to the diary measurement. The present study again addresses the issue of reactivity, since this phenomenon may still occur with a more extended time schedule of several weeks and a higher density of recording of several assessments per day.

Investigations of the fluctuations of pain intensity within one day yielded systematic trends during the course of the day (Glynn and Lloyd, 1976a,b; Jamison and Brown, 1991): Most frequent was an increase in pain intensity from the morning to the evening (Glynn and Lloyd, 1976a,b; Jamison and Brown, 1991), but a U-shaped trend was also found with pain being worst both in the morning and in the evening (Jamison and Brown, 1991; Vendrig and Lousberg, 1997). The largest increase in pain over the day occurred in female patients and in patients who did not work out of house (Glynn and Lloyd, 1976a,b), while patients who exhibited no trend in pain over the day were found to be more emotionally distressed (Jamison and Brown, 1991). In the present study, trends in pain will be explored across the 4 weeks of diary recording and will be investigated within days, while controlling for the impact of gender, work status and emotional distress as potential predictors of the daily trend.

Pain report usually increases with the progression from the acute to the chronic pain state (Sedlak, 1985; Burton et al., 1995; van der Kloot et al., 1996) and patients with persisting pain were shown to have suffered from more severe pain in the acute phase than patients whose pain resolved (Potter and Jones, 1992; White et al., 1997). Whether pain duration is also related to temporal characteristics of pain is unknown. More evidence has been obtained for a positive association between pain duration and increased disability and general psychopathology (Sedlak, 1985; Vallfors, 1985; Iezzi et al., 1992; van der Kloot et al., 1996). One exception to these findings are the results of Philips and Grant (1991), who found that pain, sickness impact and downtime decreased, and exercise increased, 3 and 6 months after the onset of the pain. Furthermore, pain duration was found to be related to less adaptive coping with pain: Burton et al. (1995) compared patients who suffered from pain for, respectively, 3 weeks and 3–52 weeks and found increased 'catastrophizing' of the pain problem in the patients with longer pain duration. The present study examines the impact of pain duration by comparing patients, who had suffered from pain for 3–6 months, for 6–12 months and for longer than 12 months with regard to pain intensity, temporal characteristics of pain, coping with pain, disability and general psychopathology.

The choice of constructs formulated in the diary of this study relied to a large extend on findings from questionnaires used in cross-sectional studies of pain. Diary measurements reflect the actual state of the subject and adequately capture variables, characterized by constant change, such as pain or mental and behavioral aspects of psychological functioning, which largely depend on the context of the moment or situation (Stone and Shiffman, 1994). Psychological questionnaires, in contrast, aim to represent more stable personality characteristics. It is therefore of interest to investigate to what extend and for which constructs the diary scores are in accordance with those obtained with psychological questionnaires. Two studies investigated the association between diary measures and scales of the Multidimensional Pain Inventory (Flor et al., 1991; Lousberg et al., 1997). With the exception of substantial association between MPI pain severity and the average pain intensity in the diaries of $r = 0.75$ and $r = 0.61$, respectively, the associations were weak or not statistically significant. To our knowledge the association between cross-sectional and diary measures of coping with pain and of disability have not as yet been established. Our study offers the opportunity to investigate these associations, since it included questionnaire and diary measures of these constructs.

The research questions of the present study can be summarized as follows.

1. Is pain report stable during 4 weeks of high-density diary recording in patients with (sub)chronic pain and what are the temporal characteristics of pain during the day?
2. Is pain duration associated with pain intensity, temporal characteristics of pain, coping with pain, disability and general psychopathology?
3. What is the accordance between intensive diary assessments and scores from cross-sectional questionnaires of the same constructs in patients with (sub)chronic pain?

A subsequent paper will review the within-subject associations between the variables and the psychosocial predictors of pain report and disability.

2. Methods

2.1. Subjects

Eighty male and female patients who had suffered from pain without an established cause for at least 6 weeks and were aged between 18 and 60 years were recruited for participation in the study. Subjects were required to have good command of the Dutch language and to be capable of operating a hand-held (palmtop) computer. Recruitment continued until 80 patients with valid diary data were recruited

consisting of two groups of 40 patients matched for pain location, sex, age and education with a pain duration of (1) shorter than or equal to 12 months or (2) longer than 12 months. Seven subjects were excluded in the process of recruitment due to insubstantial pain or problems in keeping the diary.

Of the 80 participants, 44 were recruited from a larger sample of patients ($n = 344$) participating in a national survey study of the prevalence of CBPD among adults in general practice in the Netherlands (Kerssens et al., submitted). Recruitment was also conducted through physiotherapists ($n = 30$) and a newspaper announcement ($n = 6$) in order to find enough patients with a pain duration of less than 12 months. In the two groups, mean pain duration was 7.2 months and 125.6 months, respectively.

In order to establish whether the participants in the diary study represented the CBPD patients in the Netherlands, the demographic and pain characteristics were compared to the total sample of the CBPD survey study. Data are shown in Table 1.

Both the diary and the survey sample comprised more woman than man, and the proportion of woman did not significantly differ between the samples (Fisher's exact test $P = 0.269$). Marital status was comparable but – due to the age restriction of 60 years – patients in the diary study were significantly younger than those in the survey sample ($P < 0.01$). In addition, patients in the diary sample had a higher education (chi-square = 10.6, $P = 0.032$), were less often retired (chi-square = 14.1, $P = 0.007$) and as a consequence of the deliberate selection of patients with a relatively short duration of pain for the diary study, had pain with of significantly shorter duration ($P < 0.001$). Last, the diary study included more patients with pain in the neck and the back than the CBPD sample of the survey study, a difference due to the recruitment through physiotherapists, who see many patients with these particular types of pain.

In order to assess the association of pain duration with various disease variables (see Table 2), the group with pain shorter than or equal to 12 months was broken down in patients who had suffered from pain from 3–6 months ($n = 15$) and 6–12 months ($n = 25$). These two subgroups were again comparable with respect to age, sex and marital status. Education was somewhat higher in the patients with pain for 3–6 months and they worked full-time more often, but these differences were not significant.

Table 2 displays characteristics of pain, medication use and co-morbid conditions of the patients with pain duration of 3–6 months, 6–12 months and longer than 12 months. Pain severity according to the MPI was equal in the three groups of patients, but pain location according to the IASP classification differed: compared to both groups with pain shorter or equal to 12 months, considerably more patients with pain longer than 12 months reported pain in more than three major sites of the body. Most of these patients were diagnosed with fibromyalgia. The use of analgesic and other pain medications was similar for all patients; about half of the patients used non-steroid analgesics while opioid analgesics were hardly used. Co-morbid physical conditions occurred in all groups, with 11 patients having two ($n = 9$) or more ($n = 2$) diseases in addition to the pain.[1]

Table 1
Comparison of the diary sample to the general population of CPD patients in the Netherlands

	Diary sample ($n = 80$)	Survey sample ($n = 344$)	Difference
Pain duration (months)[a]	66.4 (86.0)	133 (143)	$P < 0.001$
Age (years)[a]	40.6 (6.7)	48.0 (12.9)	$P < 0.001$
Sex (%female)	78%	71%	$P = 0.269$
Marital status			$P = 0.408$
Single	6.2	7.8	
With partner	86.3	78.1	
Separated	5.0	8.4	
Widowed	2.5	5.7	
Education			
College	8	10.7	$P = 0.032$
Trade school/business	35	18.9	
High school	19	25.9	
Vocational training	27	29.9	
Elementary school	11	14.6	
Employment			
Full time	18.8	22.3	$P = 0.007$
Part time	21.2	20.3	
Disability pension	40.0	34.6	
Retirement	0.0	11.5	
Unemployed/ homemaker	20.0	11.2	
IASP classification			$P < 0.001$
Head/face/mouth	6.5	12.0	
Cervical	32.5	10.9	
Shoulders/upper limbs	14.3	14.7	
Thoracic	0	6.8	
Abdominal	3.9	5.8	
Lower back/spine	22.1	14.0	
Lower limbs	6.5	12.8	
Pelvic	0	1.0	
Anal/genital	0	1.6	
More than 3 major sites	14.3	20.5	

[a] Mean (SD).

2.2. Measurement

2.2.1. Cross-sectional questionnaires

At the start of the study sociodemographic data and IASP classification of the pain problem were obtained and patients completed the Multidimensional Pain Inventory-Dutch version (MPI-DLV; Kerns et al., 1988; Lousberg et al., 1999), a shortened version of the SF-36 health survey (Ware and Sherbourne, 1992; Ware et al., 1993), and the Brief Symptom Inventory (BSI, Derogatis and Melisaratos,

[1] Differences between the groups in pain location, medication and co-morbidity were not tested for significance as the expected numbers per cell were too small to allow for Chi-square testing.

Table 2
Pain characteristics, medication use and co-morbid conditions in the diary sample

	3–6 months ($n = 15$)	6–12 months ($n = 25$)	> 12 months ($n = 40$)	Total group ($n = 80$)	Difference
Pain duration (in months)[a]	4.3 (0.8)	8.9 (2.5)	125.6 (88.9)	66.4 (86.0)	$P < 0.001$
MPI pain severity[a]	4.1 (1.8)	4.0 (1.0)	4.2 (1.4)	4.1 (1.3)	$P = 0.827$
IASP classification (%)					
Head/face/mouth	6.7	0	10.5	6.5	
Cervical	40.0	37.5	23.7	31.2	
Shoulders/upper limbs	33.3	12.5	5.3	13.0	
Thoracic	0	0	0	0	
Abdominal	0	8.3	2.6	3.9	
Lower back/spine	13.3	25.0	21.1	20.8	
Lower limbs	0	8.3	5.3	5.2	
Pelvic	0	0	0	0	
Anal/genital	0	0	0	0	
More than 3 major sites	6.7	8.3	31.6	19.5	
Use of medications (n)					
Non-opioid analgesics	8	14	21	43	
Opioids	1	1	2	6	
Anti-migraine	0	1	2	3	
Antidepressant	2	2	3	4	
Sedatives	2	4	5	11	
Miscellaneous[b]	4	2	12	18	
Co-morbid conditions (n)					
Hypertension	1	1	7	9	
Cardiac problems	0	2	1	3	
Asthma	2	2	4	8	
Chronic bronchitis	0	0	2	2	
Allergy	2	3	2	7	
Stomach/intestinal	1	2	6	9	
Diabetes	0	2	1	3	
Hyperthyroidism	0	2	0	2	
Epileptic condition	0	0	1	1	

[a] Mean (SD).
[b] For asthma (5), stomach/intestines (4), epilepsy (2), hypertension (1), coughing (4), infection (1) and hormones (1).

1983), the shortened version of the SCL-90. The Coping Strategy Questionnaire (CSQ, Rosenstiel and Keefe, 1983; Dutch version: CPV, Spinhoven et al., 1994) was incorporated in the study design in a later phase and consequently completed by subjects 6 months after filling out the first set of questionnaires.

The *MPI* contains 12 scales for 'pain severity', 'interference of pain with daily activities', 'life control', 'affective distress', 'social support', spouse responses to pain behavior in terms of 'punishing responses'/'solicitous responses'/ 'distracting responses', 'household chores', 'outdoor work', 'social activities' and 'general activities'. The MPI also allows for a classification of pain patients as either the 'Dysfunctional', 'Interpersonally Distressed', 'Adaptive Coping' or 'Average' type. Patients without a spouse ($n = 2$) could ignore the spouse response scales, and accordingly were also omitted from the final MPI classification. Ten items of the *SF-36* that were already covered by other instruments in this study were excluded. The scales included were: 'physical functioning', 'social functioning', 'role functioning', 'mental health', 'vitality' and 'subjective health'. The *BSI* assesses 9 aspects of psychological functioning: 'somatization', 'obsessive-compulsiveness', 'interpersonal sensitivity', 'depression', 'anxiety', 'hostility', 'phobic anxiety', 'paranoid ideation' and 'psychotism'. Finally, the *CSQ* evaluates the use of 6 cognitive coping strategies: 'diverting attention', 'reinterpretation of pain', 'positive self-talk', 'ignoring/ denying pain', 'praying and hoping' and 'catastrophizing'.

2.2.2. ESM measurement and diary

Data were collected for 4 weeks by means of the Experience Sampling Method (ESM) (Delespaul, 1995). ESM is a signal-controlled diary method for the repeated recording of momentary state measures within the real-life environment. It is particularly valuable for the investigation of the dynamics of physical, mental and behavioral processes and their interactions, because of the large number of measurements, prompted by a randomized beep signal. ESM is unbiased by anticipation or retrospection, unobtrusive and comes closest to a direct in vivo observation of a subject or patient (de Vries, 1992; de Vries and Delespaul, 1993).

For the present study, the ESM-diary was implemented on a palm-top computer (PTC), shown to be well suited for ESM research (Affleck et al., 1996; Sorbi et al., 1996).

Table 3
Representation of scales of the MPI, SF-36 and CSQ in the ESM-diary

Scale of questionnaires	Corresponding items in the ESM-diary
MPI pain severity	How much pain do I experience right now?
MPI interference of pain with daily activities	(What was I doing at the time of the beep?) My pain hindered me in doing this
MPI affective distress	Right now I feel depressed
MPI social support	I am satisfied about the support I experienced today (evening diary)
MPI punishing responses	He/she is annoyed with me
MPI solicitous responses	He/she is particularly kind[a]
	He/she spares me
	He/she takes over duties
	He/she takes care of me
MPI distracting responses	He/she encourages me to go on
	He/she encourages me to be active
SF-36 physical functioning	Right now I am capable of sitting[a]
	Right now I am capable of standing
	Right now I am capable of walking
	Right now I am capable of climbing a stair
	Right now I am capable of running
	Right now I am capable of performing activities that are moderately strenuous (such as vacuum cleaning)
	Right now I am capable of performing activities that are highly strenuous (such as moving furniture)
SF-36 role functioning	I am satisfied with how I dealt with my work/with household chores today (evening diary)
	I am satisfied with how I dealt with my family or with my partner today (evening diary)
SF-36 vitality	Right now I feel tired
	Right now I feel burned-out
CSQ[b] catastrophizing	Right now I think it is terrible to have such pain[a]
	Right now the pain is to much for me
	Right now I feel that I will never be well again
CSQ[b] ignoring/denying pain	Right now I ignore the pain[a]
	Right now I just go on in spite of the pain
CSQ[b] positive self-talk	Right now I keep my spirits up
CSQ[b] diverting attention	Right now I distract my attention from pain by thinking of other things

[a] A composite score of these items was made.
[b] For the CSQ only 4 of the 6 cognitive scales were represented in the ESM-diary.

PTC's increase the reliability of ESM by controlling the signal times, by preventing the subject to review own records and by registering the exact signal and response times as well as the number of missing recordings. Our patients were prompted four times per day by a beep signal that occurred randomly within 4 pre-determined time frames between 08:00 and 21:30 h. Unanswered signals were repeated after 5 min, and if still not responded to were coded as missing recordings. In case of inconvenience (e.g. when attending church or a concert), subject could voluntarily skip one beep in succession. In addition to the recording of 4 signal-controlled diaries per day, the subject was requested to activate the PTC immediately after waking up and before going to sleep to keep a morning diary and evening diary, respectively.

Pain intensity was measured in all of the diaries. In addition, the signal-controlled diary (84 items) measured pain cognitions, pain coping, responses to pain behavior by significant others and aspects of disability; the morning diary (12 items) assessed sleep quality and the evening diary (30 items) assessed sickness leave, medical consumption and satisfaction with role functioning. All items were formulated according to ESM premises, i.e. mimicking the internal dialogue of the respondent (e.g. 'right now, I feel...'). Where possible, the diary items were adapted from questionnaire items: each scale of a given questionnaire was usually represented by one or a few items; several questionnaire items, however, which either overlapped or were too detailed, were aggregated into one item. Table 3 shows the scales of the MPI, SF-36 and CSQ that were represented in the ESM-diary and how these were translated into ESM-items.

Most items were answered on 7-point scales, anchored: 1 = not at all, 4 = moderate, 7 = very much, or 1 = none, 4 = moderate, 7 = severe for pain intensity. A randomly changing response option of the scale was highlighted when an item occurred on the screen of the PTC and subjects could respond by scrolling across the scale and press the enter-key. Yes/no answers were also used and provided by pressing 'Y' or 'N'; open-answers were incidentally required and could be typed in on the keyboard. Each diary ended with an opportunity for comments and with thanks for the recording. The appearance of many items depended upon the presence of pain; other items depended on the presence of significant others. Because of this conditional occurrence, the number of items presented in the signal-controlled diary ranged between 31 and 84. The total diary took about 5 min to complete. A pilot study with 4 CBPD patients demonstrated the feasibility of the method and proved that the procedure was well-tolerated (Peters and Sorbi, 1997).

2.3. Procedure

Participants were visited at home by one of the researchers for a 1-hour instruction and demonstration of the PTC and ESM-diary. After explaining the general procedure and obtaining an informed consent from the subject, the diary was practiced and difficult questions were discussed. Hereafter, the PTC with the diary, four spare batteries, an extra

RAM-disk, two pre-stamped return envelopes and a manual for the PTC diary were left with the subject. Telephonic assistance was made available in the case of problems and participants were contacted by telephone 2–3 days later for a briefing. After 2 weeks of data collection, the subject was prompted in the morning diary to change the RAM-disks. The first RAM-disk was mailed to the researchers, who checked the quality and quantity of the data. The subjects were then contacted by phone for a second briefing, in which feedback regarding their data was provided and general inquiries about the proceedings were made.

After 4 weeks of diary recording one of the researchers collected the PTC and a debriefing interview was held about the general experiences of the subject, significant events during the sampling period and problems encountered with the diary. All subjects received a remuneration of 100 Dutch guilders.

The quality and quantity of the total data set per subject were checked again, subjects with invalid data ($n = 7$) were excluded and recruitment continued until two matched groups of 40 patients were complete.

2.4. Characteristics of the diary data

All 80 subjects considered the 4-week period of diary recording as representative of their normal life, according to the debriefing interviews. The mean number of diary entries was 108.4 (range 41–140, see Table 4): 79 subjects produced 77–140 entries while one subject, who encountered an exceptionally large number of technical problems and was therefore dismissed after 2 weeks, had only 41 entries. The PTC was carried for exactly 4 weeks by 74 subjects, three subjects carried it between 3 to 4 weeks and two subjects carried it somewhat longer than 4 weeks to compensate for missed diaries. Table 4 displays the mean numbers of the three types of diary entries as well as the numbers and percentages of diaries not recorded due to, respectively, technical problems with the PTC, unanswered signals and signals skipped voluntary by the subject.

About 12% of the signals where either skipped or not responded to, while 5.1% were missing due to technical problems with the PTC, such as empty batteries or errors made when exchanging the RAM-disks. This left us with a total of 7146 recorded signal-controlled diaries (mean 89.3, range 30–115). No information was obtained about the reasons for non-response to signals. Inspection of missing data revealed that non-response was not related to time of day; quite often two or more beeps in succession were missed, suggesting that the PTC may have been left home while patients were away.

The mean number of both the morning and evening diaries was 27.2 (range 13–35); 4.4% of morning diaries and 5.7% of evening diaries were skipped by the subjects and comparable percentages of entries (3.5% and 4.4%, respectively) were lost due to technical problems. Completed were 1979 morning diaries (mean: 24.7; range: 4–32) and 1937 evening diaries (mean: 24.2; range: 4–32). The most probable reason for skipping morning and evening diaries is forgetting: patients were not signaled for these diaries.

2.5. Data analysis

All analyses were performed using SPSS 7.5.3 (SPSS Inc, 1996). Stability of pain intensity during the 4 weeks of diary recording was tested by means of ANOVA for repeated measurements with 'week' as the within-subject factor. Linear trending of pain intensity during one day was tested by regressing standardized pain intensity data (z-score transformation) on time of day in hours for all subjects. In addition, for each individual patient the presence of first, second and third order trends was established using a curve fitting procedure. Chi-square analyses were used to test whether the presence or absence of trending could be related to pain duration.

Between-group differences on cross-sectional assessments were tested with ANOVA. Bonferroni pair-wise post hoc comparisons were applied to significant between-group differences. Multilevel analyses (MLN; Bryk and Raudenbush, 1992; Goldstein, 1995) were employed to assess between-group differences in the ESM-diary assessments. Multilevel models are designed to analyze variables at different levels simultaneously using a statistical model that includes the various dependencies. The present analyses accounted for three levels of variance (time, day, subject) in the signal-controlled diary and for two levels of variance (day, subject) in the evening diary. The three patient groups were coded by means of two dummy variables in such a way

Table 4
Numbers of diary entries and percentages of missing values in the diaries

		Number of diary entries	Missing diary entries due to		
			Technical problems	Voluntarily skipped signals	Unanswered signals
Signal-controlled diaries	Mean	108.4 (41–140)	5.5 (0–27)	1.7 (0–22)	11.6 (0–49)
	%		5.1% (0–25.7)	1.5% (0–19.6)	10.6% (0–44.1)
Morning diaries	Mean	27.2 (13–35)	0.9 (0–7)	1.2 (0–10)	
	%		3.5% (0–25.9)	4.4% (0–35.7)	
Evening diaries	Mean	27.2 (13–35)	1.2 (0–14)	1.6 (0–23)	
	%		4.4% (0–52)	5.7% (0–85.2)	

Table 5
Pain intensity, missing diaries and diaries with no pain in the 4 weeks of diary recording

	Pain intensity, mean (SD)	Total missing sc-diaries[a] (%)	Skipped sc-diaries (%)	sc-diaries with no pain (%)
Week 1	3.67 (1.98)	8.2	0.95	26.5
Week 2	3.66 (2.03)	10.9	1.93	28.9
Week 3	3.70 (2.04)	10.2	1.65	29.2
Week 4	3.61 (2.08)	13.0	1.80	29.3

[a] sc-diaries: signal-controlled diaries.

that (1) the group with 3–6 months of pain was compared to the groups with pain for 6–12 and longer than 12 months and (2) the groups with pain for 3–6 and 6–12 months were compared to the group with pain longer than 12 months. In order to eliminate the variance induced by time per se, the data set was controlled for potential linear and U-shaped trends in the time-of-day prior to these comparisons.

Last, the accordance between ESM- and cross-sectional assessments was tested by computing Pearson's rank correlations between the scores on the respective questionnaire scales and the averaged diary scores representing the same constructs (see Table 3). The MPI subscales on spouse behavior were correlated to the respective diary items only on those occasions that the spouse was present, i.e. responses to pain by another person were disregarded.

3. Results

3.1. Mean pain intensity, stability of pain recording and temporal characteristics of pain during the day

The mean pain intensity in the 7146 signal-controlled diaries was 2.66 (SD: 2.0).[2] There were large differences between patients: mean pain intensity ranged from 0.4 to 6.0 and no pain was recorded in 0-88% (mean: 29%) of the signal-controlled diaries. Twenty-one patients (26%) recorded pain in all of their diaries, while 26 patients (33%) were free of pain in half or more of their diary recordings.

Regarding the stability of pain recording addressed in research issue 1, Table 5 provides the means for pain intensity, the percentages of missing diary recordings and diary entries with no pain per week.

No significant effect of week on pain intensity was found ($F(1, 7144) = 0.446$, $P = 0.50$).[3] There was, however, a small but significant linear increase in both the percentage of missing diaries ($F(3, 73) = 7.15, P < 0.001$, linear trend: $F(1, 75) = 12.4$, $P = 0.001$) and the percentage of skipped diaries ($F(3, 73) = 3.0$, $P = 0.036$, linear trend: $F(1, 75) = 5.25$, $P = 0.025$). The percentage of pain-free diaries also increased somewhat, but this did not reach significance ($F(3, 73) = 0.95$, $P = 0.423$).

Regarding the temporal characteristics of pain during the day, the second part of research issue 1, standardized pain intensity scores were plotted against time of the day for all patients. This revealed a systematic linear trend, with more severe pain occurring later in the day. Linear regression showed that hour of the day significantly predicted pain intensity (beta = 0.155, $P < 0.001$). The trend was also supported by comparison of the average morning and evening pain scores with each of the pain intensity means per hour of the day: mean pain intensity in the morning was lower (mean = 2.3, SD = 2.0), whereas mean pain intensity in the evening was higher (mean = 3.1, SD = 2.1) than all of the mean pain intensity scores per hour.

However, not all patients showed an increase of pain intensity during the day: a significant linear trend of increased pain intensity occurred in 38 and of decreased pain intensity in two subjects; a significant U-shaped trend was found in two subjects and no significant trend was found for the remaining 38 subjects. In the light of previous findings, we then tested whether differences between individuals in trending could be ascribed to emotional distress (BSI), sex or work status: the trending in pain intensity during the day had no association with, respectively, distress (BSI), sex and work status, nor did we find any significant difference in daily trends in pain intensity between, respectively, male and female patients or patients who did and did not work outside of the house (respective betas were 0.14 for men, 0.16 for women, 0.16 for work and 0.15 for no work).

3.2. Comparison of patients varying in pain duration

Research issue 2 concerns the association between pain duration and various aspects of the pain problem, disability and general psychopathology. The three patient groups were first compared with regard to their scores on the cross-sectional questionnaires. The CSQ was not used in this comparison as it was administered 6 months later, when most patients had already entered the chronic phase. Significant differences between the groups were found for the subscales 'Interference of pain with daily activities' (MPI), 'physical functioning' and 'subjective health' (both SF-36) and 'obsessive-compulsiveness' (BSI). Post-hoc comparisons showed that patients with pain for 3–6 months

[2] With 0 = no pain and 6 = severe pain. For purposes of comparison with the MPI pain severity scale, the ESM scale (1–7) was recorded to a 0–6 scale.

[3] Analyses are based on 76 subjects for which 4 weeks of data-collection were available.

showed less interference, better functioning and less obsessive compulsiveness than patients with pain for more than a year. Subjective health was best in patients with pain for 6–12 months and they differed significantly from patients with pain of longer duration. It should be noted that for only four of the 27 subscales tested significant differences between patient groups were found; if correction for multiple comparisons would have been applied statistical significance is lost.

Research issue 2 also covers the between-group differences of several of the above constructs as measured with the ESM-diary (see Table 3). First, between-group differences were tested regarding the trends in pain intensity during the course of the day, which were reported earlier. Chi-square analyses showed that the presence or absence of trending in pain intensity, as well as the slope of the curves representing these trends, did not significantly differ between the groups (respective beta's were 0.13, 0.18 and 0.15). Fig. 1 provides a graphical presentation of the pain intensity curves per group over the day. Multilevel analysis (MLN) was used to test for differences on the other constructs measured in the diary. Table 6 summarizes the results.

Measurement with the ESM diary revealed that patients with longer pain duration reported a significantly higher pain intensity, averaged per day and calculated separately for the morning and evening diaries. Patients with pain for 3–6 months reported a significantly lower pain intensity than the two other groups. For exploratory reasons, we also tested whether patients with pain in more than three major sites of the body ($n = 15$) differed from patients with pain in less than three major sites ($n = 65$). Pain in more than three sites was associated with a non-significant increase in pain intensity averaged per day and a non-significant increase in pain in the morning and in the evening. As the above reported effect of pain duration may have been confounded by number of pain sites (more than three major sites was found most frequently in patients with more than 12 months of pain), the analysis was repeated for patients with less than three major sites only. For total pain during the day the group difference now just failed to reach significance (chi-square = 3.5, df = 1), but pain in the morning and evening diary was still significantly different for patients with less than 6 months pain in comparison to the other groups.

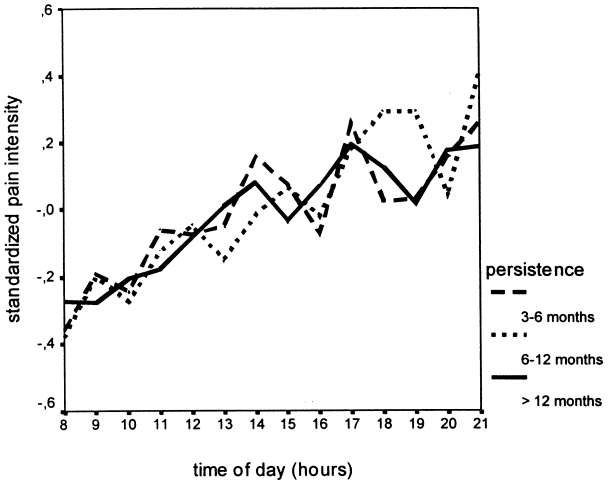

Fig. 1. Comparison of the temporal course over the day of standardized pain intensity z-scores according to pain duration in the diary sample.

The MLN also revealed that patients with a pain duration of more than one year experienced significantly more solicitous and more distracting responses to their pain from spouses than patients with pain for 3–12 months. In accordance with the significant between-group differences in physical functioning as measured with the SF-36, physical capacity measured with the ESM-diary also showed a significant difference. Patients with pain for 3–6 months reported significantly better physical capacity than patients with pain duration of 6 months or longer. In addition, patients with pain for 3–6 months experienced significantly more vitality than the other patients.

Between-group differences in pain coping could not be assessed with the CSQ, but 4 of the 6 CSQ strategies were covered by the ESM-diary (see Table 3). According to the diary recordings patients with pain for 3–12 months catastrophized their pain to al lesser degree but also ignored and denied their pain less than patients with pain persisting for 12 months or longer.

3.3. Accordance between ESM-diary assessments and cross-sectional questionnaires

In order to answer research issue 3, correlation coefficients were computed between averaged diary score per subject and the questionnaire score of the same construct. For each subject the mean pain intensity was calculated separately on the basis of the signal-controlled diaries, the morning diaries and the evening diaries. In addition, a mean overall pain intensity score was established by averaging the mean intensity scores for the morning diaries, the signal-controlled diaries and the evening diaries. These four averaged pain intensity diary scores were then correlated with the MPI pain severity score, obtained most proximate in time to the diary recordings.[4]

Pain severity according to the MPI was significantly higher than overall pain intensity in the diary (4.0 vs. 2.8, paired $t = 6.21$, df = 62, $P < 0.001$); a scatter plot showed that almost every subject reported more severe pain on the MPI than in the diary. In addition, MPI pain severity correlated significantly but moderately with mean pain intensity in the diary (overall: $r = 0.40$; signal-controlled diary: $r = 0.40$; morning diary: $r = 0.34$; evening: diary

[4] The MPI was filled out every 3 months. The MPI-item for 'pain severity' covered pain intensity 'during the last week'. Since pain intensity may change over time, the analysis was restricted to the MPI scores of 63 subjects, which were obtained no longer than 4 weeks before or after the diary sampling period.

Table 6
Comparison of the diary scores representing scales of the MPI, SF-36 and CSQ according to pain duration in the diary sample[a]

	Group 1, 3–6 months	Group 2, 6–12 months	Group 3, > 12 months	Chi-square[b]
MPI				
Pain intensity per day	1.91 (1.57)	2.76 (1.82)	2.83 (1.73)	$4.5^{1/2,3}$
Morning pain intensity	1.32 (1.71)	2.34 (2.04)	2.57 (1.97)	$8.4^{1/2,3}$
Evening pain intensity	2.20 (2.00)	3.44 (2.08)	3.21 (2.05)	$5.1^{1/2,3}$
Interference of pain	3.43 (1.66)	3.43 (1.84)	3.57 (1.81)	ns
Distress	1.89 (1.21)	1.99 (1.39)	2.24 (1.56)	ns
Social support	5.16 (1.39)	4.91 (1.45)	5.08 (1.70)	ns
Punishing responses	1.19 (0.61)	1.18 (0.71)	1.27 (0.81)	ns
Solicitous responses	7.61 (6.65)	7.75 (7.00)	9.85 (8.17)	$6.1^{1,2/3}$
Distracting responses	3.51 (3.08)	3.08 (2.38)	4.23 (3.47)	$5.2^{1,2/3}$
SF-36				
Physical capacities	4.49 (1.08)	3.98 (1.34)	3.75 (1.24)	$4.0^{1/2,3}$
Satisfaction work	4.60 (1.42)	4.40 (1.60)	4.41 (1.61)	ns
Satisfaction family	5.52 (1.38)	4.61 (1.65)	4.99 (1.61)	ns
Burn-out	2.65 (1.56)	3.39 (1.88)	3.36 (1.84)	$4.4^{1/2,3}$
CSQ				
Catastrophizing	9.17 (3.67)	9.94 (4.03)	11.42 (3.95)	$5.4^{1,2/3}$
Ignoring/denying	3.25 (1.69)	3.17 (1.61)	4.13 (1.83)	$6.1^{1,2/3}$
Positive self-talk	3.61 (1.56)	3.70 (1.80)	3.74 (1.96)	ns
Diverting attention	4.69 (1.33)	4.19 (1.60)	4.16 (1.80)	ns

[a] Values are mean (SD).
[b] A chi-square of 3.84 or above with df = 1 is significant at $P < 0.05$. $^{1/2,3}$ signifies that group 1 differs significantly from groups 2 and 3. $^{1,2/3}$ signifies that groups 1 and 2 differ significantly from group 3.

$r = 0.43$). These moderate correlations may be due to the time lag between both types of measurement, even though this was never longer than 4 weeks. The analysis was therefore repeated for 12 subjects who had filled out the MPI *during* the 4 weeks of diary recording, selecting the diary scores of the week, covered by the MPI measurement: the correlation for overall pain improved to $r = 0.70$ ($P = 0.01$), but relied heavily on two subjects, one with zero pain and one with maximum pain on both instruments. Again most subjects overestimated pain on the MPI as compared to the diary, but the difference was no longer significant (4.0 vs. 3.3, $t = 1.83$, df = 11, $P = 0.095$).

Significant but moderate correlations with the diary scores were also obtained for most of the remaining MPI scales: $r = 0.34$ for 'interference of pain with daily activities', $r = 0.42$ for 'affective distress', $r = 0.51$ for 'social support', $r = 0.53$ for 'solicitous responses' and $r = 0.53$ for 'distracting responses'. The MPI scale for 'punishing responses' did not correlate significantly with the diary item supposed to capture this aspect.

Of the SF-36 scores 'physical functioning' correlated highly with the mean score of the diary items for 'physical capacities' ($r = 0.73$). The scale 'role functioning' correlated significantly ($r = 0.38$) with the diary item for 'satisfaction with dealing with work or household', but not with 'satisfaction with dealing with family or partner'. The SF-36 vitality scale correlated moderately but significantly with the diary items for fatigue ($r = -0.34$) and burn-out ($r = -0.33$).

The CSQ scale 'catastrophizing' correlated considerably with the composite diary score for 'catastrophizing'(r = −0.66), while moderate correlations of $r = 0.41$ were found between the CSQ scales 'diverting attention' and 'ignoring/denying pain' and the respective diary items. 'Positive self-talk' yielded no significant correlation.

4. Discussion

The present study employed a 4-week electronic ESM-diary to study temporal characteristics of pain intensity in patients differing in duration of unexplained pain. The procedure was easily accepted and well tolerated by the subjects and produced reliable recordings: the 4 weeks of diary measurement accurately represented normal life in all subjects. The response rate of 88% is comparable to previous studies using electronic ESM-diaries (Shiffman et al., 1994; Sorbi et al., 1996), although the use of a financial reward for each completed diary yielded response rates as high as 99% (Affleck et al., 1996, 1998). Nevertheless, in view of the relatively long period of sampling and the substantial number of questions per diary, compliance can be considered good. Importantly, missing observations only increased slightly across the 4 weeks of recording, and were randomly distributed across time of day.

Research issue 1 pertained to the stability of pain report and the temporal characteristics of pain during the day. Mean pain report did not change during the 4-week recording period. This confirms the finding of previous diary studies that pain report is stable over time (Kerns et al., 1988; von Baeyer et al., 1994; Cruise et al., 1996) and is not in accordance with the idea that response decay may

occur as a result of boredom or fatigue with the task of daily recordings in longitudinal studies (Stone et al., 1991). Although the number of omitted and skipped diaries increased somewhat from week 1 to week 4, mean pain report for the remaining diaries was stable across the weeks. Another potential danger of our diary, not as yet alluded to, may be induced by the electronic branching of questions in the PTC: the answer 'no' to the pain item induced the omission of 50% of the questions per diary. It is therefore conceivable that subjects may have learned to avoid the recording of long diaries by denying their pain. This was, however, not supported by the data: the number of pain-free diaries did not increase during the 4 weeks and day-to-day frequencies of 'no pain' yielded no significant trending over the days. We therefore conclude that longer and more intensive diary sampling than used in previous studies produced no evidence for reactivity to the repetitiveness of the recording.

With regard to the temporal characteristics of pain during the day a significant trend of pain intensity increasing from morning to evening was found, averaged over all subjects. This is in agreement with earlier findings of Glynn and Lloyd (1976a,b) in patients with pain from various causes. But individual testing revealed that a significant trend in pain intensity occurred in only 53% of our subjects (linear increase: 47%; linear decrease: 3%; U-shaped trend: 3%), while pain intensity showed no trending at all in the other 47% of the subjects ($n = 38$). This is similar to the results of Jamison and Brown (1991), who reported a linear increase in 35% and no trend in 36% of patients. However, they also reported the presence of second order trends (U-shaped in 8% and inverted U-shaped in 14%). Most likely, the absence of an inverted U-shaped trend in pain intensity in our study is due to the timing of the last diary assessment per day: in our study this was between 18:30 and 20:30 h, whereas Jamison and Brown employed hourly pain ratings during the entire waking time, thus probably until much later in the evening. In some patients pain intensity may start to decrease later in the evening, parallel to a decrease in physical activity.

Our study did not confirm the additional finding of Jamison and Brown that patients with no trending in daily pain were more emotionally distressed than patients with pain trending: no differences were found between the two groups on the nine separate scales and on the total score of the BSI. Neither could the difference between male and female patients and between working and non-working patients in the slope of pain increase (Glynn and Lloyd, 1976a) be confirmed in this study. Thus, although patients with chronic benign pain demonstrate clear differences in the trending of pain intensity during the day, we were not able to identify characteristics discriminating between patients with and without trends.

Research issue 2 concerned the association between pain duration and various aspects of the pain problem, disability and general psychopathology. Pain behavior, disability, depression and general psychological distress supposedly increase as pain progresses from the acute to the chronic stage (Sedlak, 1985; Vallfors, 1985; Iezzi et al., 1992; van der Kloot et al., 1996). On the other hand, adaptation to pain and disability may also occur in the course of time (Philips and Grant, 1991). The present study was not a prospective, longitudinal study following the same cohort of patients over time and therefore differences between patients groups with various duration of pain may not be the result of duration per se. However, if anything, our results are more in line with the first hypothesis: patients with pain for 3-6 months – i.e. patients whose pain is not yet chronic according to the IASP definition – had pain of a lower intensity (diary), were less burned-out (diary) and physically disabled (SF-36 and diary) and reported less interference of pain with daily activities (MPI) than patients with pain for 6 months or longer. With regard to general psychopathology only one of the nine BSI scales, 'obsessive-compulsiveness', yielded a significant between-group difference with higher scores in patients with longer pain duration. With regard to the issue of pain coping, our study confirmed the finding of Burton et al. (1995) of less adaptive coping with pain, i.e. increased 'catastrophizing' of the pain problem in the patients with longer pain duration. Unexpectedly, patients with pain for longer than 12 months also ignored and denied their pain more than patients with pain for 3–12 months. Last, patients with pain for longer than 12 months received more solicitous responses but also more distracting responses to their pain from spouses.

Thus it appears that the association between pain duration and interference and disability was most prominent if patient groups with a cut-off point of 6 months were contrasted. In contrast, coping strategies and spouse responses to pain differed most between patients when a cut-off point of 12 months was used. Unfortunately, we did not include patients with pain for less than 3 months, which – in view of the finding of Philips and Grant (1991) that the major changes in pain and interference of pain occurred already in the first 3 months of pain, and more or less stabilized between 3 to 6 months of pain – could have been the group contrasting most with patients with longer pain duration.

Research issue 3 focused on the accordance between measures of the same constructs obtained with the ESM-diary and with cross-sectional measurements with the MPI (pain severity, interference of pain, affective distress, social support as well as punishing, solicitous and distracting responses to the pain problem by the spouse), the SF-36 (physical functioning, role functioning, vitality) and CSQ (catastrophizing, denying/ignoring pain, positive self-talk and diverting attention).

Most MPI scales correlated significantly but moderately with equivalent diary items (range: $r = 0.33$–0.53). This agrees with a previous study (Lousberg et al., 1997), although most of our correlations were somewhat lower. The moderate associations in our study may partly be

explained by the difference between instruments in both the exact wording of items and the number of items used to represent a construct. The moderate correlation between MPI pain severity and the diary item for pain intensity may be somewhat surprising because singular items, highly similar in terminology were used and because 3 comparable studies in this respect produced correlations of $r = 0.75$, $r = 0.61$ and $r = 0.64$ (Kerns et al., 1988; Flor et al., 1991; Lousberg et al., 1997). But although differences between the time frames of the assessments with the MPI and with the diary were comparable to the two earlier studies, our study yielded a lower correlation of $r = 0.40$. It therefore seems likely that the lower correlations in the present study is due to the remaining difference in diary procedure. The earlier studies applied paper-and-pencil diaries, which allow the subject to determine the moment of recording and scroll through recordings already completed, and which require assessments, not restricted to the singular moment of recording but covering a stretch of time. Paper-and-pencil diaries thus provide relatively low control over response tendencies in the subjects. The electronic ESM-diary may produce more accurate momentary state measures of the variables under study since the moment of the recording is determined and the inspection of previous recordings prevented by the PTC. However, while paper-and-pencil diaries are more susceptible to response tendencies, which may increase the stability of the measurement, the electronic ESM-diary may be more susceptible to situational influences, which increases the variability of the recordings. It could thus very well be that the lower correlations in our study are at least partly due to the diary method employed in measuring actual momentary states.

In this context it is noteworthy that almost every subject in our study reported more severe pain on the MPI than in the ESM-diary and this was confirmed in 12 subjects whose MPI and diary assessments covered exactly the same week. It is conceivable that retrospection bias accounts for this difference. Subjects tend to overestimate negative events in the process of recollection (Fahrenberg et al., 1996) and patients may thus have overestimated the severity of their pain in the retrospective assessment with the MPI. This is consistent with the conclusion of a review study of memory for pain demonstrating that recall of pain in chronic pain patients is inaccurate and frequently an overestimation in comparison to actual state measures of pain (Erskine et al., 1990).

The measures for physical disability in the SF-36 and in the ESM-diary correlated highly ($r = 0.73$). This suggests that physical disability is a relatively stable characteristic, not subject to momentary changes within a 4-week measurement period. Two other scales of the SF-36 (role functioning and vitality) correlated moderately but significantly with the corresponding diary items. This may again reflect the fluctuations in these characteristics, especially since role functioning was defined in the diary as role satisfaction.

Four of the CSQ strategies of coping with pain were represented in the ESM-diary. A substantial correlation between the CSQ and the ESM-diary was found for catastrophizing ($r = 0.66$), while moderate correlations of $r = 0.41$ were found for, respectively, diverting attention and ignoring/denying pain. The last strategy, positive self-talk, yielded no significant correlation, but this may have been due to a wording of the diary item according to the ESM premise of mimicking the internal dialogue that differed considerably from the terminology in the CSQ.

All in all, the electronic ESM diary seems to be highly sensitive in measuring the dynamics of physical, mental and behavioral processes that are intrinsically characterized by constant fluctuation, such as pain intensity and mental or behavioral responses to situational cues. The ESM-diary identified differences between patients with, respectively, sub-chronic, recently chronic and longstanding chronic pain with regard to pain intensity, vitality and responses to the pain provided by others, differences which were not detected with the cross-sectional questionnaires. This cannot be attributed to the greater power and scrutiny in accounting for different sources of variance of the multilevel analyses of the diary scores, because ANOVA of scores averaged per individual largely gave the same results (data not shown). Thus, electronic ESM assessment is a sensitive method, particularly appropriate to capture the subtle differences in actual states. In addition, it is a convenient method, which was well tolerated even during 4 weeks of continuous assessment.

One of the disadvantages of electronic diary assessment can be the difficulty in handling the apparatus for some people. Even though answering the questions in itself is not very difficult, exchanging RAM-cards and batteries can be. At least some training will always be necessary. Finally, electronic devices are never completely error proof, and – as our results show – data may be lost due to technical errors. Stand-by assistance to handle technical errors should be available.

In spite of these considerations, electronic diaries seem a suitable method to gain insight into the dynamics of pain severity, pain behavior and the psychosocial determinants of pain. Questions can be asked or omitted in a flexible manner and a subsequent step to take will be the development of an interactive device for use in future research.

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