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Within-person relationships among pain intensity, mood and physical activity in chronic pain: a naturalistic approach

Alexander A. Vendrig[a,*], Richel Lousberg[b]

[a]Rug AdviesCentra Nederland, Utrechtseweg 92, 3702 AD Zeist, The Netherlands
[b]Chronic Pain Center, University Hospital Maastricht, Postbus 616, 6229 ER Maastricht, The Netherlands

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Abstract

Fifty-seven chronic pain patients rated their pain intensity, mood and activity level, at a random time schedule, eight times a day during 6 consecutive days, according to the Experience Sampling Method (ESM). Within-person correlations among pain intensity, mood and activity level were calculated. We found pain intensity to be significantly associated with mood. However, the associations between pain intensity and activity level, and activity level and mood could not be supported. Further, we examined whether the relationship between pain intensity and mood was the result of a pattern across the day. Results showed that pain intensity and mood were worst in the morning and improved during the afternoon among participants whose pain intensity and mood were correlated significantly. We suggest that attentional as well as behavioural processes might explain the established day pattern of pain intensity and mood.

Keywords: Chronic pain; Depression; Activity; Experience sampling method (ESM)

1. Introduction

Research on behavioural and cognitive characteristics of chronic pain patients can be conducted using different designs; the between-person design is most frequently used. Correlations among variables or differences between groups are based on the variability between different people. Questionnaires which are only administered once provide the greatest amount of data; a within-person design is less frequently used. Such a design requires repeated longitudinal measurements.

Utilising a between-person design, relationships among depression, pain intensity and activity level have been established and explained in cognitive-behavioural formulations. Several investigators have found that depressed chronic pain patients report higher levels of pain intensity (Magni, 1987; Haythornthwaite et al., 1991). Evidence also exists that especially chronic pain patients with lowered activity levels are prone to develop a depressive mood (Rudy et al., 1988). The relationship between pain intensity and activity level is somewhat more complex. Though it is unequivocally accepted that chronic pain patients have rather low levels of activity compared to normals (though certainly not all chronic pain patients have lowered activity levels), there is a discrepancy between patients' global report of activity and their actual level of physical (motor) activity (Linton, 1985). This discrepancy may be due to differences in measures of activity used and their underlying definitions, ranging from pure exertion tests to self-reports of social and general activities (e.g., the Multidimensional Pain Inventory; Kerns et al., 1985). Contrary to the reported negative between-person association between pain intensity and activity level, one may expect this correlation to be positive at the within-person level. This may be as a result of increased activity leading to a temporary increase of pain.

In spite of the numerous cross-sectional studies on relationships among pain intensity, depression and activity level, little is known about how these variables interact when compared to daily functioning. Some prospective

* Corresponding author. Tel.: +31 30 6916677; fax: +31 30 6918989.

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daily studies have examined the characteristics and correlates of daily changes among chronic pain patients (Linton, 1985; Linton and Götestam, 1985; Persson and Sjoberg, 1987; Affleck et al., 1991, 1992, 1996), but none have investigated how pain intensity, mood, and activity level fluctuate and correlate across the day. For this purpose, time based methods such as the experience sampling method (ESM) are particularly useful. ESM uses self-reports after repeated random signals to examine the variability of the variables of interest in patients' natural setting (DeVries, 1987). ESM has been applied in several psychiatric populations (DeVries, 1992) and good reliability and validity figures have been reported (Csikszentmihalyi and Larson, 1987; DeVries, 1987). ESM has important advantages over cross-sectional measures. First, the problem of global and retro-spective recall can be avoided by utilising this method (DeVries, 1987). Secondly, hourly fluctuations of variables can be examined. Thirdly, an individual response bias (e.g., exaggeration) can be avoided since responses of the same person are compared and analysed.

The current study was an initial effort to examine within-person relationships among pain intensity, mood and activity level of chronic pain patients using ESM. The basic question was whether between-person (positive) relationships among pain intensity and depressed mood, and lowered activity level and depressed mood as shown by several authors (e.g., Magni, 1987; Rudy et al., 1988; Haythornthwaite et al., 1991) can be demonstrated using a within-person design such as ESM. Finally, we were interested whether significant within-person correlations among pain intensity, mood and activity level were the result of a pattern across the day.

2. Methods

2.1. Sample description

The sample consisted of 57 chronic pain patients who were referred to the Chronic Pain Center of the University Hospital Maastricht in the Netherlands. Participants were screened after an initial consultation with the neurologist at the Chronic Pain Center. Those patients who agreed to participate and who met the inclusion criteria were included in this study. With the exception of a few, almost all of the initially approached patients agreed to participate. The inclusion criteria were: (a) duration of pain 6 months or longer; (b) having a significant other; (c) pain was not related to cancer; (d) age between 18 and 65 years; and (e) no evidence of severe psychopathology such as attempting suicide. Participation was rewarded with a small financial compensation.

After the screening procedure, 57 patients (26 males, 31 females) were included in this study. The mean age of participants was 42.3 years (range 21–65, SD = 10.0). The mean duration of pain was 7.1 years (range 1–33, SD = 7.5). Among the participants 32% had low back pain, 11% had headache, 32% had a diffuse pain pattern (more than three pain locations), and 34% had pain in other parts of the body (e.g., lower limbs, pelvic region).

2.2. Experience Sampling Method

Participants were given a Seiko RC-1000 alarm wristwatch that was programmed to go off eight times a day, between 8:30 h and 22:30 h, over 6 consecutive days. In most cases, the experience sampling experiment started on a Tuesday morning and lasted until Sunday night. The signals were presented in a random time schedule. At each signal participants were asked to report pain intensity, mood and physical activity. For each day one booklet was available. The maximum amount of responses was 48 (eight signals $\times$ 6 days). If participants were temporarily hindered, they could turn off the signal, resulting in different response frequencies among participants. ESM self-reports completed 15 min or longer after the signal were regarded as 'invalid' and discarded before analysis.

Seven-point Likert scales (0–6) were used to assess pain intensity, mood and activity level. Pain intensity ranged from 'no pain' (0) to 'very much pain' (6), and mood ranged from 'very negative mood' (0) to 'very positive mood' (6). To achieve some objectivity for the activity rating, descriptions of activity were attached to the end-points of the activity scale from 'rest, lying, doing nothing' (0) to 'heavy physical work' (6). We were interested in the actual level of physical activity, not in the perceived level of physical activity. We wanted to avoid some subjects calling, for example, walking '1', while others called this '6'.

2.3. Statistical analysis

Within-person correlations (r) were calculated using the matched variables pain intensity/mood, pain intensity/activity level, and mood/activity level. Both within-person r's as well as mean r's ($\bar{r}$'s) of within-person r's of the matched variables were tested on statistical significance ($P < 0.05$). Next, for the three pairs of variables, it was decided whether the mean r ($\bar{r}$) reached statistical significance ($P < 0.05$). In that case/those cases, participants with significant r's ($P < 0.05$) were compared with the rest of the sample on day patterns of pain intensity, mood and level of activity using a repeated measures design (MANOVA). The between-group factor was groups (participants with a significant within-person r versus participants without). The within-subject factor was 'signal' (moments of the signals). The three dependent variables were pain intensity, mood and activity level. With this procedure it is possible to explain within-person variance to fluctuations of the variables across the day. Normality of distributions (an assumption of MANOVA) of samples was tested using the One-Sample Kolmogorov-Smirnov Test. Skewed distributions (about 1/3 of all samples) were found on the activity level scale due to a relative high amount of low scores (0 and 1), indicating a low level of activity. However, except for a few exceptions, the distributions of the pain intensity and mood scales were normally distributed.

3. Results

3.1. Compliance to signals

The maximum amount of possible responses (per case) was 48 for each variable. Because in this study responses were used to calculate correlations, the amounts of valid responses assessed listwise are of interest. The means of valid responses (listwise) were: pain intensity/mood, 42.4 (88.3%; SD = 5.3); pain intensity/activity level, 41.1 (85.6%; SD = 6.6); and mood/activity level, 42.2 (87.9%; SD = 6.9).

3.2. Within-person correlations (Pearson *r*)

Mean scores (means of all signals) of variables are: pain intensity: 3.5 (SD = 1.3); mood: 2.9 (SD = 0.5); and physical activity: 1.2 (SD = 0.6).

Means of the within-person correlations among pain intensity, mood and activity level are presented in Table 1. $\bar{r}_1(n_1)$ represents the overall means and numbers of the within-person correlations, while $\bar{r}_2(n_2)$ and $\bar{r}_3(n_3)$ represent the means and numbers of the significant ($P < 0.05$) within-person correlations in the expected ($\bar{r}_2$) and unexpected ($\bar{r}_3$) direction respectively. As can be seen from Table 1, the mean within-person correlation between pain intensity and mood is moderate, whereas the mean within-person correlations between pain intensity and activity level, and activity level and mood were almost zero. The means of all individual r_1's ($\bar{r}_1$) per paired variables ($\bar{r}_1$ pain intensity/mood; $\bar{r}_1$ mood/activity level; and $\bar{r}_1$ pain intensity/activity level, respectively) can be tested for statistical significance by transforming the individual *r*'s to *z*-scores (Fischer's *r*-to-*z* transformation). After applying this transformation, it emerged that the mean correlation ($\bar{r}_1$) of pain intensity/mood was significant (*t*-test, $P < 0.05$), whereas mean correlations of pain intensity/activity level, and mood/activity level were both non-significant (*t*-tests, *P*'s > 0.05).

3.3. Day patterns of pain intensity, mood and activity level

As a result of our interest in finding out whether significant within-person correlations among pain intensity, mood and activity level were the result of a pattern across the day, we restricted this examination to the relationship between pain intensity and mood. To investigate whether the within-person relationship between pain intensity and mood was the result of a pattern across the day, the mean day patterns of pain intensity and mood of participants with a significant within-person correlation between pain intensity and mood were compared with those of the rest of the sample. In Fig. 1A, the mean day patterns of pain intensity, mood and activity level are presented for those participants ($n = 19$) with a significant within-person pain intensity/mood correlation; in Fig. 1B the mean day patterns of pain intensity, mood and activity level of the rest of the sample ($n = 38$) are presented. Each line of Fig. 1A consists of about 850 measure points (maximum of eight signals × 6 days × 19 participants), while each line of Fig. 1B consists of about 1700 measure points (maximum of eight signals × 6 days × 38 participants). Visual inspection of Fig. 1A and 1B shows that pain intensity and mood differ in shape; in Fig. 1A both pain and mood are worst in the morning and evening and improve during the middle of the day until afternoon, whereas pain and mood are almost equal during the day in Fig. 1B. The day pattern of activity level is almost the same in both figures. Differences in day patterns of pain intensity and mood were tested using multivariate repeated analyses of variance. Day pattern of pain intensity differed significantly ($F(9,44) = 2.55$, $P < 0.05$) between groups, whereas day pattern of mood was marginally significantly different ($F(6,48) = 2.08$, $P = 0.074$) between groups.

As a group, participants with a significant correlation between pain intensity and mood (Fig. 1A) had a significantly ($t = 2.63$, $P < 0.05$) higher level of pain intensity (Fig. 1A: 4.1, SD = 1.0; Fig. 1B: 3.2, SD = 1.5) and a significantly ($t = 2.52$, $P < 0.05$) worse mood (Fig. 1A: 2.7, SD = 0.5; Fig. 1B: 3.0, SD = 0.5), but had about the same

Table 1

Means of within-person correlations (*r*) among pain intensity, mood and activity level

	Overall		Expected		Unexpected	
	$\bar{r}_1$	(n_1)	$\bar{r}_2$	(n_2)	$\bar{r}_3$	(n_3)
Pain intensity/ mood	–0.22	(47)	–0.51	(19)	0.44	(4)
Mood/ activity level	0.01	(50)	0.34	(7)	–0.37	(5)
Pain intensity/ activity level	0.06	(56)	0.40	(15)	–0.41	(6)

$\bar{r}_1$ represents the overall mean of the within-person correlations; $\bar{r}_2$ represents the mean of the significant ($P < 0.05$) within-person correlations in the expected direction; $\bar{r}_3$ represents the mean of the significant ($P < 0.05$) within-person correlations in the unexpected direction. The number of participants (n_1) is not equal in the three conditions (47/50/56) because some participants were excluded from analysis because of no variability in responses resulting in a denominator of 0 in the Pearson formula.

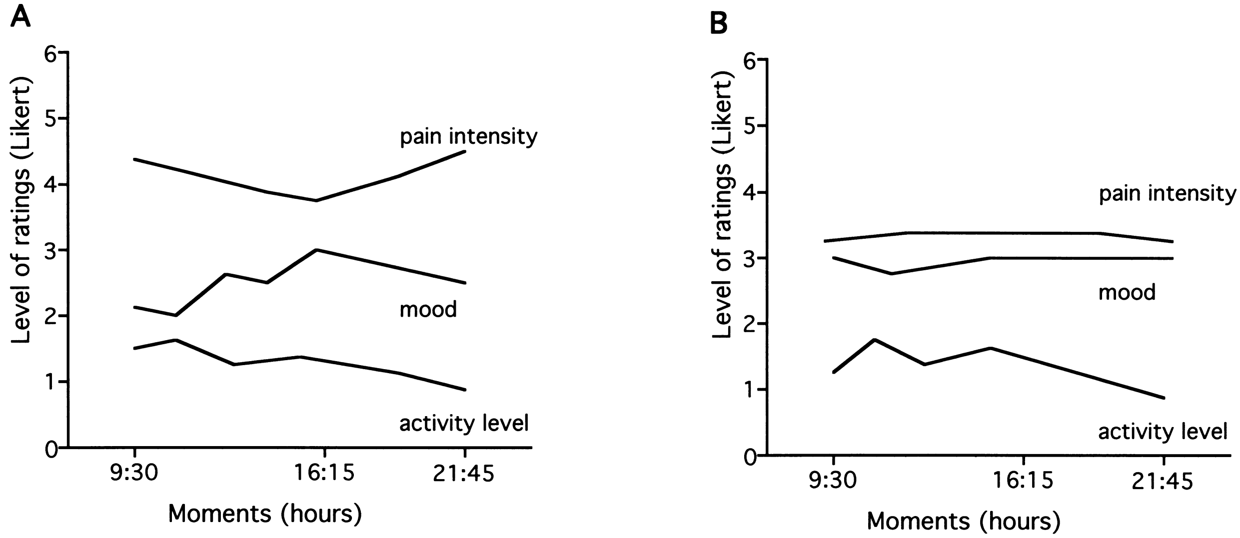

Fig. 1. (A) Day patterns of pain intensity, mood, and activity level of participants with a significant ($P < 0.05$) within-person pain intensity/mood correlation. (B) Day patterns of pain intensity, mood, and activity level of participants without a significant pain intensity/mood correlation.

($t = 0.92$, $P = 0.36$) activity level (Fig. 1A: 1.3, SD = 0.7; Fig. 1B: 1.1, SD = 0.6).

4. Discussion

In this study relationships among pain intensity, mood and activity level were investigated using a within-person design. Importantly, measurement took place in the patients' daily life using the Experience Sampling Method (ESM). This is the first study applying ESM with chronic pain patients and it also broke new ground by examining patterns among pain intensity, mood and activity level across the day.

In the first part of this study, we analysed within-person relationships among pain intensity, mood and activity level. Support was found for a negative within-person relationship between pain intensity and mood (in 1/3 of the sample pain intensity and mood were correlated significantly), but not for relationships between pain intensity and activity level, and between mood and activity level. Distribution of the within-person correlations between pain intensity and mood demonstrated that for some subjects, pain and mood were associated quite well, whereas for others not at all. This observation stresses the importance of looking beyond group findings. At the within-person level an association between variables may have some other meaning compared to the between-person level. The mean within-person pain intensity/mood correlation was somewhat lower than Linton and Götestam (1985) reported. This difference is most likely due to the method used. In the study of Linton and Götestam (1985), subjects had to rate variables once a day, whereas our participants gave eight ratings daily. Given pain intensity and mood do not change within hours, our correlations will be less sizeable.

Though it is a commonplace that depressed chronic pain patients are less 'active' than non-depressed patients (Haythornthwaite et al., 1991), we found no evidence that such a relationship exists at the within-person level. This contradiction might be due to different measures of activity used. We focused on the level of concrete physical activities whereas Haythornthwaite et al. (1991) used self-report questionnaires, which merely assess the perception of activity. Thus, one might speculate that depressed chronic pain patients are less active in the sense that they are 'passive', are less socially active, but not necessarily less physically active. But more research is needed to confirm this speculation because of the lack of comparative studies.

The absence of any within-person relationship between pain intensity and level of (physical) activity is in line with previous cross-sectional research (Fordyce et al., 1984; Linton, 1985). However, 'fear-avoidance beliefs' (Waddell et al., 1993; Vlaeyen et al., 1995) may explain why patients report pain intensity and activity level to be associated: patients with more 'fear-avoidance beliefs' will report both a higher pain level as well as a lower activity level (though they are not necessarily physically less active). This also explains why such a relationship has been established using cross-sectional self-reports of activity.

The second part of this study examined whether the established within-person relationship between pain intensity and mood can be explained by fluctuations of these variables across the day. We found such evidence: both pain and mood were worst in the morning and evening and improved during the afternoon. It is interesting to speculate about possible explanations for this finding. Firstly, it is a well-known fact that attention (Arntz et al., 1991) and (emotional positive) distraction (McCaul et al., 1992) regulate the experience of pain. Thus, higher pain levels during morning and evening hours may be the result of an increased attendance to pain or less distraction during these times. Secondly, according to operant conditioning theory, one might speculate that during morning and evening hours there is an increase of pain behaviour contingencies resulting in the report of higher pain levels. The effect of pain-contingencies, particularly regarding patient-spouse interaction, on pain report has been demonstrated experimentally by several researchers (Flor et al., 1987; Gil et al., 1987; Lousberg et al., 1992). One should notice that both explanations regard the increase of pain intensity to be responsible for fluctuations of mood. Thirdly, there is increasing evidence that several chronic pain conditions are associated with non-restorative, or unrefreshing sleep (Moldofsky et al., 1975; Fisher and Chang, 1985; Anch et al., 1991), and that poorer sleepers report more pain (Affleck et al., 1996). Concerning the variability of wake-up and sleeping time, higher levels of pain and mood disturbance during morning and evening hours can be regarded as the consequence of sleep disturbances. Finally, one could also speculate about central disturbances such as diurnal rhythms of cortisol effecting both depressed mood and pain intensity, although such explanations seem not to be so likely because hypercortisolism in depression has been associated with an increase of depressed mood during morning hours, but not in the evening (Späth-Schwalle et al., 1991).

Some limitations of this study should be acknowledged. Four participants reported a substantial positive correlation between pain intensity and mood. Probably the direction of the mood scale was falsely interpreted by these participants. An other explanation might be that these patients are willing to pay the 'cost' of increased pain in order to obtain satisfaction and pleasure from certain activities. Thus, pain rises with a desired and rewarded activity. With respect to the multivariate repeated analyses of variance it should be noted that the number of subjects was rather small, though the purpose of these analyses was merely explorative rather than confirmative. Next, we did not analyse the within-person data set using multi-level statistics like, for example, a pooled regression model (Jaccard and Wan, 1993). By using such techniques, subjects with and without significant within-person correlations would have all been mixed up, which may have clouded the results. Our main interest was to study day patterns of pain intensity and mood of those subjects with significant within-person correlations of these variables. To accomplish this task, our measurement methods were felt to be justified.

In conclusion, time-based research on patients' daily life yields information that may be concealed using a cross-sectional design. The ascertained day patterns of pain intensity and mood could be an interesting point of discussion regarding behavioural, attentional and physiological disturbances in chronic pain. To form an empirical basis for discussion, further research is needed to replicate or extend our findings. Next to fundamental research questions, time-based studies may also offer opportunities for clinical practice, in particular regarding assessment procedures.

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