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The effect of past-injury on pain threshold and tolerance

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Summary Forty male veterans who had been injured during their military service in the Israeli Defense Forces were assessed for pain threshold and tolerance in a thermal pain procedure. Based on their medical records, subjects were classified by three independent judges as having been either severely or lightly injured. Veterans who had been severely injured had much higher threshold and tolerance for thermal pain as compared to lightly injured veterans. These results are interpreted as supporting adaptation-level theory, which implies that painful experiences can change the internal anchor points for the subjective evaluation of pain.

Key words: Pain threshold; Pain tolerance; Chronic pain; Adaptation-level theory

Introduction

A common finding is that chronic pain patients, who suffer pain over long periods of time, typically exhibit higher than normal thresholds for various types of experimental pain (Merskey and Evans 1975; Wolskee and Gracely 1980; Naliboff et al. 1981; Cohen et al. 1983; Yang et al. 1985; Peters et al. 1989; Peters and Schmidt 1992). There are two hypothesized explanations of this finding — one appealing to a neurophysiological mechanism and the other to a cognitive mechanism. The neurophysiological model has been termed 'diffuse noxious inhibitory control' (DNIC) and involves descending inhibition of nociceptive activity at the spinal level. This inhibition originates at the brain stem, and is activated by noxious stimulation originating at any part of the body (Le Bars et al. 1979; Le Bars and Willer 1988). Such a mechanism can account also for the known pain-alleviating properties of including acupuncture, transcutaneous nerve stimulation (TENS) and other counterirritation procedures which involve painful stimulation. Whereas the site and duration of stimulation vary widely, pain relief persists for up to several hours beyond the period of treatment in all cases (Mayer and Frenk 1988). Furthermore, the duration of this analgesic effect can be prolonged by classical conditioning in animals. Thus, in studies where painful foot shock serves as the unconditioned stimulus, analgesia becomes the conditioned response (Watkins et al. 1982). This conditioned analgesia is mediated by opioid mechanism as indicated by its sensitivity to the specific opiate antagonist naloxone (Watkins et al. 1982).

The cognitive account for the higher pain threshold in chronic pain patients is based on the adaptation level theory (Helson 1964), which suggests that evaluation of pain severity depends on the context in which the pain occurs. When the context is chronic pain, the 'internal anchor points' for pain severity are shifted up, thus lowering the subjective severity of the experimental pain (Rollman 1979).

Recently, several studies provided evidence in support of the cognitive, rather than the neurophysiological hypothesized mechanism. Thus, Peters et al. (1992) found that whereas both chronic low back pain patients and patients with postoperative pain from oral surgery had higher pain thresholds than pain-free subjects, these groups did not differ in nociceptive flexion reflex (RIII), which was taken as a measure of spinal nociceptive processes. Furthermore, naloxone did not lower pain threshold or RIII in any of the groups. The authors concluded that the higher pain threshold in the two pain group did not reflect DNIC, and that "a

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perceptual mechanism based upon the adaptation level theory seems to be the best hypothesis at present" (p. 184). In a different study, Boureau et al. (1991) found that chronic pain did not affect pain threshold, tolerance, and RIII, but was related to a higher 'unpleasantness threshold'. These authors also interpreted their findings in terms of adaptation level theory.

The attempt to contrast the two theoretical models using chronic pain patients, however, is problematic. To begin with, the finding of decreased sensitivity to acute pain in these patients is inconsistent. Several studies found chronic patients just as sensitive or even more sensitive than normals to certain pain stimuli on various tests of threshold, tolerance and habituation (Malow et al. 1980; Schmidt and Brands 1986; Brands and Schmidt 1987). A possible explanation, consistent with DNIC theory, is that the endogenous opiate system, which is activated by painful stimuli and stress, develops tolerance as a result of its chronic activation, hence becoming less effective in producing the descending pain inhibitory signals which are also opioid dependent. A second problem is that both hypothetical mechanisms, the physiological and the cognitive, may well operate together, and there is no way to separate them in a group of patients who suffer ongoing pain, which can activate both hypothetical mechanisms. As a result, while the DNIC mechanism has independent empirical support, as described above, there is no independent support for the hypothetical cognitive mechanism.

The problems presented above can be overcome by measuring pain perception and tolerance in subjects who had suffered significant pain in the past, but are not currently experiencing chronic pain. In such subjects, changes in pain sensitivity can be attributed to past-pain rather than to ongoing pain. Furthermore, involvement of factors that complicate studies with chronic pain patients, such as the use of analgesics and other pain treatments, is minimized. Finally, in the absence of ongoing pain, it can be claimed that DNIC should not be operative in such subjects, and therefore, decreased sensitivity to acute pain can be attributed to a cognitive change in anchor points for pain as a result of the pain experienced in the past. The present study sought to approximate such an investigation by studying army veterans who had been severely injured in the past but are presently not treated for pain.

Method

Subjects

Forty male veterans who had been injured during their military service in the Israeli Defense Forces (IDF) volunteered to participate in the study. None were undergoing medical treatment or using any medications, including pain medications, at the time of the study. The study was conducted in an IDF social club for army personnel injured during their military service, which the subjects were visiting primarily to use its free gym and pool facilities.

For the purpose of the study, subjects were classified as having been either severely or lightly injured. Subjects were classified into these 2 categories by 3 independent clinicians (1 physician and 2 physical therapists) in a university medical center. Each clinician was given a detailed description of the injuries, as well as the type and number of treatments they required and the length of hospitalization, if any. Based on this information, the clinician was asked to classify each injury as light or severe. The three clinicians were in perfect agreement in regard to this classification, which resulted in 16 subjects in the severely injured group and 24 subjects in the lightly injured group. Severe injuries included, for example, crushed bones, severe burns and amputated limbs, whereas light injuries included torn ligaments, broken hands, and appendicitis. Five subjects in the lightly injured group and 11 in the severely injured group were wounded in battle and the remaining sustained non-combat, mostly training, injuries.

Procedure

Subjects were seated in front of a small (25×50 cm) Plexiglas whirlpool containing water at 48°C. The temperature was monitored with a laboratory thermometer and regulated by a thermostat which kept it stable (±0.02°C). Subjects were asked to dip the first 2 joints of their index finger in the hot water. They were asked to report as soon as the sensation of heat became painful, and then to keep their finger in the water as long as they could bear. The procedure was terminated after 60 sec, and the subject was asked to remove his hand from the water if he had not done so earlier. The period of time it took subjects to report initial feeling of pain was the measure of pain threshold, and the total time until they withdrew their hand was the measure of pain tolerance. The complete procedure was carried out for both hands in random order, and the results reflect the mean of the 2 hands.

Following the thermal pain procedure, subjects were interviewed with a structured pain questionnaire. Among other questions, they were asked to rate the severity of the pain associated with their original injury on a 7-point scale (with 1 = Very light, 4 = Moderate and 7 = Very severe). On other 7-point scales, subjects rated the extent to which the pain associated with their injury was predictable (with 1 = Very unpredictable and 7 = Very predictable), and controllable (with 1 = Very uncontrollable and 7 = Very controllable), and the extent to which it was similar to the experimental pain in terms of both quality and severity (with 1 = Very different and 7 = Very similar). Subjects were also asked to rate how much they were suffering from pain compared to the average person (with 1 = Much less, 4 = The same and 7 = Much more) and how frequently they were experiencing pain (with 1 = Never, 4 = Sometimes and 7 = Every day).

Results

A comparison between lightly and severely injured subjects on non-experimental variables is presented in Table I. Two-tailed t tests, with alpha set at 0.01 to control for family-wise type-I error rate, were used to test for group differences. The only significant difference between the groups was that the severely injured subjects were hospitalized for longer periods of time than the lightly injured subjects ($t(38) = 7.88$; $P < 0.01$). Compared to the lightly injured group, severely injured subjects rated the pain of their original injury as slightly

TABLE I

COMPARISON BETWEEN LIGHTLY AND SEVERELY INJURED VETERANS

	Severely injured	Lightly injured
Age at time of injury	30.62	33.00
	(7.59)	(10.45)
Number of Years since injury	16.12	13.88
	(6.52)	(6.91)
Painfulness of injury (1–7)	6.31	5.23
	(1.81)	(1.79)
How predictable injury pain was (1–7)	4.17	4.62
	(2.22)	(1.96)
How controllable injury pain was (1–7)	3.25	3.69
	(1.96)	(1.58)
Similarity to experimental pain (1–7)	2.62	1.69
	(1.66)	(0.70)
Number of months of hospitalization	9.25	1.59
	(3.45)	(2.69)
Usual level of pain (1–7)	4.62	4.00
	(1.36)	(1.14)
Usual frequency of pain (1–7)	4.31	3.04
	(2.02)	(1.40)

more severe, less predictable and controllable and more similar to the experimental pain, and reported a somewhat higher level and frequency of current pain; however, none of these differences were statistically significant.

Measures of pain perception in the 2 groups were compared by planned contrasts (2-tailed t tests), with alpha set at 0.01. The results showed that the severely injured subjects had much higher pain threshold and tolerance than the lightly injured subjects (see Fig. 1). The mean pain threshold in the lightly injured group

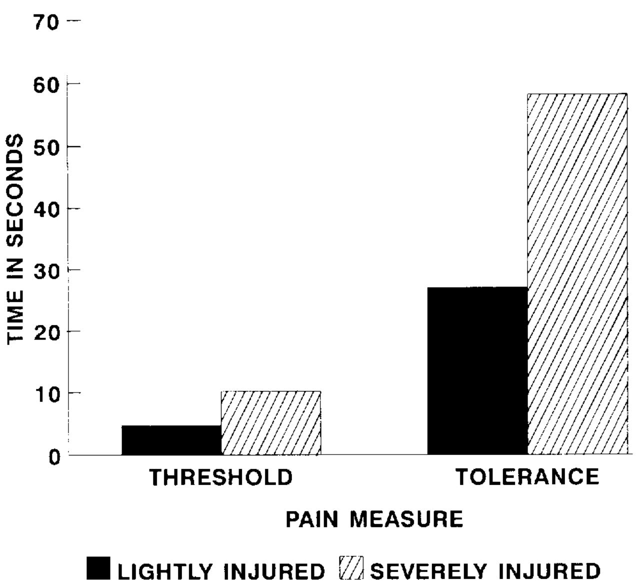

Fig. 1. Mean pain threshold and tolerance for lightly and severely wounded subjects. SEMs were between 0.43 and 3.0.

was 4.69 sec (SD = 2.11) as compared to 10.13 sec (SD = 6.21) in the severely injured group ($t(38) = 3.98$; $P < 0.01$). Similarly, pain tolerance was 27.02 sec (SD = 14.69) in the lightly injured group, compared with 58.09 sec (SD = 7.63) in the severely injured group ($t(38) = 7.81$; $P < 0.01$). Strikingly, whereas in the severely injured group all but 1 subject reached the cutoff point of 60 sec, none did so in the lightly injured group. Pain threshold and tolerance were not significantly correlated with any of the variables appearing in Table I, including the amount of time since the injury occurred, the severity of the pain associated with that injury, the extent to which it was predictable and controllable, and its similarity to the experimental pain.

Discussion

The present results show that soldiers who had been severely injured during their military service had significantly higher threshold and tolerance for thermal pain than soldiers whose injuries were light. The differences between the 2 groups were of considerable magnitude; notably, the distributions of pain tolerance in the 2 groups did not overlap.

While the results are striking and thought-provoking, they cannot provide a definitive choice between the theoretical accounts of adaptation level and DNIC. On the one hand, the adaptation level account is consistent with two findings. First, the effect of past injury was most marked on pain tolerance, which is generally seen as reflecting higher operations, compared to pain threshold, and is more reactive to various factors such as culture, placebo, cognitive manipulations and suggestion (e.g., Melzack and Wall 1982). Second, the severely injured subjects did not rate the pain associated with their injury significantly higher than did the lightly injured subjects. This finding suggests that the severely injured subjects have shifted their internal pain scale relative to the lightly injured subjects, as predicted by adaptation level theory (Rollman 1979).

On the other hand, an explanation in terms of DNIC cannot be ruled out as well. Our results indicate that the severely injured subjects may not have been truly pain-free, despite the fact that none were receiving pain medications or any other treatment for pain. As seen in Table I, whereas lightly injured subjects rated their relative level of pain as 4 (The same) on a 7-point scale, indicating that they perceived themselves as suffering the same levels of pain as other people, severely injured subject reported somewhat higher levels of pain compared to other people. Similarly, pain frequency was rated 3 (Infrequently) on a 7-point scale by lightly injured subjects, and somewhat higher than 4 (Sometimes) on the same scale by severely injured subjects. While these differences in pain level and frequency were not statistically significant, we cannot rule out the possibility that DNIC may have been operating more strongly in severely injured subject, which may account, at least partially, for their higher threshold and tolerance. Furthermore, it is possible that nociceptive activity sufficient to activate DNIC but below the pain threshold was higher in severely injured subjects.

It is also of note that there were more battle-related injuries in the severely injured than in the lightly injured group. This fact may be significant in at least two respects. First, as one of our reviewers noted, it may threaten the implicit assumption that our subjects were the same before they were injured. No doubt, personality factors may affect not only the decision to join a low- versus high-risk unit in the army, but also how inclined one is to expose himself to the risk of severe injury and death and how willing one is to report pain. Second, it recalls Beecher's (1946) classic report, that soldiers wounded in battle, immediately following the injury, showed higher pain tolerance than victims of car accidents suffering similar injuries. Beecher's interpretation of these findings was in psychological terms: he posited that the soldiers' pain acquired a positive connotation, for it meant they were going to leave the battlefield, whereas no comparable meaning was associated with the pain of the car accident victims. As in our sample the context and severity of the original injury are confounded, Beecher's findings may be relevant. However, it is no trivial extension of Beecher's finding to claim that the context of the injury should have not just an immediate effect on pain tolerance, but also a long-term and generalized effect on pain threshold and tolerance. Whereas it seems plausible that soldiers would tolerate pain of injury better if it carried a welcome relief from danger and stress, it is difficult to extend this reasoning to the reassuring and controllable context of an experiment many years later.

Finally, as this was a first attempt at relating pain sensitivity to past injury, the self-report scales we administered following the experiment were especially created for the study, and we have no information as to their reliability and validity. Whereas this does not bear on the thermal pain threshold and tolerance, which were assessed by a well-validated procedure, it may have implications for the data related to the characteristics of the injury pain and of current pain level and frequency. Specific concerns may be raised regarding the usual pain scale, in which subjects were asked to rate their pain compared to the average person; whereas the goal of this reference was to create an external anchor for the scale, we have no knowledge about subjects' ability to use such scales reliably. A replication which would attempt to control for current pain and nociceptive activity level, incorporating better-validated scales, is therefore highly desirable.

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