Low pressure pain thresholds are associated with, but does not predispose for, low back pain

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Abstract Chronic pain is often associated with hyperalgesia in cross-sectional studies. In the present study, a random cohort of 40-year-old individuals ($n = 264$) from the general population was assessed for low back pain (LBP) status and pressure pain threshold (PPT), with follow-up assessment 4 and 8 years later. Low PPT at baseline as a potential risk factor for the development of LBP was investigated longitudinally and the association between LBP and hyperalgesia was studied cross-sectionally at baseline and 8-year follow-up. Generalized ($p < 0.03$) and localized pressure hyperalgesia ($p < 0.02$) was found in participants with long-lasting LBP, but not with recent LBP ($p > 0.08$). Of the participants without recent or long-lasting LBP, those with a low PPT at baseline (lower 10% percentile) had no increased risk of developing LBP ($p > 0.05$). The findings indicate that PPT decreases as a consequence of long-lasting pain, whereas a low PPT seems not to constitute a separate risk factor for the development of LBP.

Keywords Low back pain · Generalized hyperalgesia · Quantitative sensory testing · Central sensitization · Pressure pain threshold

Introduction

There is considerable evidence in support of an association between high pain sensitivity (e.g. generalized hyperalgesia) and a range of chronic or long-lasting pain conditions, including chronic low back pain (CLBP) [5, 7, 14, 15, 22]. Such generalized hyperalgesia may be maintained by nociception and may be modulated by changes in the afferent barrage [19, 26].

There is considerable variation in pain sensitivity in the general population [24] and an individual's constitutional pain sensitivity and characteristics of pain modulation may be important factors for the chronification (or remission) of acute clinical pain. This question has only been addressed to a lesser extent: The cohort study by Buchgreitz et al. [3] examined the changes in cranial muscle pressure pain thresholds (PPTs) over a 12-year period and found that increased pain sensitivity correlated with development of chronic tension type headache. Thus, the authors concluded that increased pain sensitivity of cranial muscles develops as a consequence of chronic headache. Such findings have not been reported for other clinical pain populations, including low back pain (LBP).

Acute LBP is a common condition with a high rate of spontaneous remission (and recurrence), most commonly managed with 'benign neglect' or inexpensive and safe conservative treatment. In contrast, CLBP is a difficult condition to manage, often idiopathic in nature and commonly exposed to a variety of non-evidence-based therapies. From a socio-economic perspective, the major impact

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of CLBP is related to massive indirect costs, e.g. early retirement, sick leave, production loss, etc., i.e. the consequences of chronification [6]. Thus, there is considerable impetus to identify risk factors for chronification of LBP.

Psychosocial factors such as distress, somatization, low job satisfactions and others are known to increase the risk of LBP chronification [13, 20, 23]. There is conflicting evidence on the importance of mechanical loading [2], but heavy physical work seems also to be a separate and significant risk factor [9]. A high constitutional pain sensitivity may represent another distinct risk factor for pain chronification.

The present study was performed in order to examine (1) the association between both long-lasting and recent LBP and localized and generalized pressure hyperalgesia and (2) whether pre-existing high pressure pain sensitivity constitutes a risk factor for future development of LBP.

Materials and methods

The longitudinal cohort study “Backs on Funen” was initiated in 1999, involving 625 40-year-old inhabitants of Funen island, Denmark, randomly chosen from the Central Office of Civil Registration.

Sixty-six percent ($n = 412$) of those invited agreed to participate at baseline and were enrolled in the study. Participants with incomplete data at follow-ups were excluded, leaving a total of 264 (135 woman) for the study.

Details of the study are published elsewhere [16, 17], but the sample was representative of the general population, apart from a slight under-representation of individuals with basic schooling and vocational training and a slight over-representation of individuals with higher education or top-managerial jobs.

Data collection at baseline, 4-year and 8-year follow-up included questionnaires on LBP status. At baseline and 8-year follow-up, PPTs were measured at five locations, on the back, arms and legs.

Permission for the study was granted by the local ethics committee (ref. no. 20000042) and for the database by the Danish Data Protection Agency (ref. no. 2000-53-0037).

LBP status

LBP status was recorded as dichotomous data (yes/no) in relation to the following indicators:

1. trouble with the lower back at the moment;
2. trouble with the lower back within the last 7 days;
3. trouble with the lower back within the last month;
4. trouble with the lower back within the last year;

5. trouble with the lower back for more than 30 days within the last year;
6. trouble with the lower back which has prompted treatment, sick leave or other non-trivial consequence within the last year.

Prior to data analysis, it was decided to truncate data on LBP status into three clinically meaningful categories: (1) long-lasting LBP, (2) recent LBP and (3) none-or-remitted LBP:

1. Participants reporting LBP for more than 30 days within the previous year were identified as ‘long-lasting LBP’ (irrespective of their answer to the other LBP questions).
2. Of those not identified as ‘long-lasting’ LBP, those who reported LBP at the moment or within the last 7 days were identified as ‘recent LBP’.
3. The remaining participants (i.e. without ‘long-lasting’ or ‘recent LBP’) were identified as none-or-remitted LBP.

Thus, participants identified as ‘long-lasting LBP’ may or may not have reported concomitant recent LBP, but participants identified as ‘recent LBP’ did not report long-lasting LBP. Similarly, participants identified as ‘none-or-remitted LBP’ may have reported episodes of LBP within the last month or year, but not recent or long-lasting LBP.

PPT

PPTs were recorded at baseline and at 8-year follow-up at the Brachioradialis muscles, at the Tibialis Anterior muscles (bilaterally) and in the mid-line over the spinous process of L4. PPT data and LBP questionnaires were collected on the same day.

As the focus of the current project was localized and generalized hyperalgesia, the four PPTs recorded from Brachioradialis muscles and Tibialis Anterior muscles were averaged into a single variable (*distant-PPT*), as an overall measure of PPT, distant from the low back. PPT at L4 was registered as *local-PPT*.

Baseline PPT

At baseline, PPTs were recorded once using a Wagner Instruments (Connecticut, USA) pressure algometer, Model FDK 20 (unit: kg/cm², converted to kPa for data analysis) with a 1 cm² probe. Pressure was increased gradually (approx. 1 kg/s) until the participant reported the pressure as becoming painful. If no pain had been induced by 16 kg/cm² (1,569 kPa), this was recorded as the PPT.

8-Year follow-up PPT

PPTs were recorded using a Somedic model 2 (Hørby, Sweden) pressure algometer (unit: kPa) with a 1 cm² probe. Pressure was increased gradually (approx. 50 kPa/s) until the participant reported the pressure as becoming painful. If no pain had been induced by 1,000 kPa, this was recorded as the PPT. If a PPT below 1,000 kPa was recorded, a second measurement was performed, approximately 30 s later and the average of the two measurements was defined as the PPT.

Low PPT in participants without long-lasting or recent LBP

For the purpose of this study and to examine the potential increased risk of LBP from a low PPT, participants identified as ‘none-or-remitted LBP’ at baseline having PPTs in the lower 10% percentile of the PPT distribution (none-or-remitted LBP only) were identified and labelled as *low-local-PPT*, *low-distant-PPT*, *low-local-and-low-distant PPT* and *low-local-or-low-distant PPT*, respectively.

Statistical analysis

The heterogeneous conditions (different examiners, equipment and procedures, including rate of force application) under which PPTs were recorded at baseline and 8-year follow-up excluded a within-subject analysis.

Data were analysed with non-parametric methods, due in part to the skewness in distributions introduced by right-censoring PPT measurements. LBP status and PPT on the same occasion (baseline and 8-year follow-up) were analysed using Mann–Whitney *U* test, to test for differences in PPTs by LBP status. A statistical significance level of 5% was accepted. PPT at baseline and LBP status at 4- and 8-year follow-up were analysed as contingency tables with relative risk calculations and one-sided Fischer’s exact test. A statistical significance level of 5% was accepted.

Results

LBP status

Self-reported LBP is summarized in Table 1. Most participants reporting ‘long-lasting LBP’ also reported (1) non-trivial consequences thereof (72, 78 and 84%, at baseline, 4- and 8-year follow-up, respectively), (2) concomitant LBP at the moment or within the last week (91, 99 and 87%) and (3) LBP within the previous month (95, 97 and 85%). A majority of participants identified as

Table 1 Low back pain status

	None-or-remitted	Long-lasting	Recent
Baseline	170	57	37
4-Year follow-up	145	67	52
8-Year follow-up	152	62	50

Cells list absolute numbers of total (*n* = 264)

Table 2 Changes in low back pain status

Baseline	4-Year follow-up		
	None-or-remitted	Long-lasting	Recent
(a) Changes from baseline to 4-year follow-up			
None-or-remitted	113	20	37
Recent	19	8	10
Long-lasting	13	39	5
4-Year follow-up	8-Year follow-up		
	None-or-remitted	Long-lasting	Recent
(b) Changes from 4- to 8-year follow-up			
None-or-remitted	101	17	27
Recent	29	10	13
Long-lasting	22	35	10

Cells list absolute numbers

‘recent LBP’ also reported LBP within the last month (86, 88 and 86%) and within the last year (97, 92 and 90%).

Conversely, fewer participants identified as ‘none-or-remitted LBP’ reported an episode of LBP within the last month (14, 11 and 9%) or within the last year (50, 48 and 49%).

Changes in LBP status

Changes in LBP status from baseline to 4-year follow-up and from 4- to 8-year follow-up are summarized in Table 2. From Table 3a, it is evident that 22% (8/37) of participants identified as ‘recent LBP’ at baseline were identified as ‘long-lasting LBP’ at 4-year follow-up.

Twenty-three percent (13/57) of participants identified as ‘long-lasting LBP’ at baseline were identified as ‘none-or-remitted LBP’ 4 years later. Similarly, 33% had remission of long-lasting LBP from 4-year to 8-year follow-up. Conversely, 12% of participants identified as ‘none-or-remitted LBP’ developed long-lasting LBP from baseline to 4-year follow-up and from 4-year to 8-year follow-up.

A total of 158 participants were not identified as ‘long-lasting LBP’ at any of the three occasions when data were collected, 86 were not identified as ‘long-lasting LBP’ or ‘recent LBP’ at any point and 26 did not report any LBP at all, on any occasion. Conversely, 23 were identified as

Table 3 Pressure pain thresholds by low back pain status

PPT (kPa)	LBP status				
	None-or-remitted (95% CI)	Long-lasting (95% CI)	<i>P</i>	Recent (95% CI)	<i>P</i>
(a) Baseline					
Local (L_4)	755 (706–805)	677 (576–748)	0.003	667 (549–867)	0.133
Distant	717 (656–769)	625 (541–716)	0.024	723 (582–904)	0.706
(b) 8-Year follow-up					
Local (L_4)	910 (833–1,000)	801 (701–887)	0.011	846 (771–930)	0.069
Distant	793 (756–850)	673 (604–773)	0.011	763 (604–829)	0.093

Median (95% CI) PPT by concomitant low back pain (LBP) status. *P* values refer to Mann–Whitney *U* test comparing *long-lasting* to *none-or-remitted LBP* and *recent LBP* to *none-or-remitted LBP*, respectively. Similar analysis comparing *long-lasting* to *recent LBP* (not listed) did not reveal statistically significant differences

‘long-lasting LBP’ at all three occasions and 238 participants reported LBP at some point, at least once.

PPTs and concomitant LBP

Table 3 summarizes PPT values for participants subgrouped by concomitant LBP status. Significantly lower local and distant PPT in long-lasting LBP was found at baseline and 8-year follow-up, compared to none-or-remitted LBP. By contrast, no statistically significant differences in PPT were found between recent and none-or-remitted LBP.

Risk of future LBP for participant without long-lasting or recent LBP

For participants identified as ‘none-or-remitted LBP’ at baseline ($n = 170$), the relative risks of developing LBP from having a low PPT were calculated for both ‘long-lasting’ or ‘recent’ LBP at 4-year or 8-year follow-up. Low PPT was any combination: low local-PPT and/or low-peripheral-PPT.

None of the resulting 16 contingency tables yielded a statistically significant risk by one-sided Fischer’s exact test. The calculated relative risks ranged from 0.54 to 1.99 and in all instances, the 95% CI included 1.0.

Discussion

Low PPTs in participants identified as ‘none-or-remitted LBP’ were not found to constitute a significant risk factor for the development of future LBP.

The data lend further support for the presence of both localized and generalized hyperalgesia in long-lasting LBP; neither were found in ‘recent LBP’.

A considerable number of participants changed LBP status during the 8-year follow-up period.

LBP status

LBP, whether recent or long-lasting, was a common finding in this study and a considerable number of participants changed LBP status during the course of the study.

There is no universal consensus of what *chronic* LBP implies and it is used interchangeably to mean irreversible and long-lasting. Thus, the terminology of *chronic* LBP has been avoided in the present study.

It would seem that long-lasting LBP, even if accompanied by non-trivial consequences and generalized hyperalgesia as reported here, does not necessarily mean irreversible LBP—the majority of participants reporting long-lasting LBP also had non-trivial consequences thereof.

Often, chronic LBP is defined in the literature simply as non-remitting pain for more than 1 month (or 3 or 6 months), yet the clinical course of LBP is often one of the intermittent remissions and recurrences [4, 11, 12, 18] and the psychosocial and economic impact of LBP is related to non-trivial consequences of LBP such as sick leave and early retirement [6]. It is thus debatable whether the sub-division of LBP by simple and arbitrary cut-off points in time is useful—arguable a definition, such as the one used in the current study, which encompasses fluctuating LBP and non-trivial consequences, is more relevant.

LBP status and hyperalgesia

The present study confirms both localized and generalized hyperalgesia in participants with long-lasting LBP, compared to those with none-or-remitted LBP. This was found to be the case in cross-sectional observations at both baseline and 8-year follow-up and corroborates previous findings [5, 7, 22]. The study by Jensen et al. [15] reported a correlation between number of tender points and intensity of LBP in a population of sub-acute and CLBP with

4–12 weeks of sick-listing. A similar conclusion was reached by Hüppe et al. [14].

The present data furthermore demonstrate that localized and generalized hyperalgesia is *not* a feature of recent LBP. It is perhaps surprising that localized hyperalgesia was not demonstrated in recent LBP; however, the nociceptive focus of such LBP may be any of a number of tissues and segments, whereas the PPT was consistently measured at L4 in the mid-line.

The finding of generalized hyperalgesia with long-lasting, but not recent LBP, agrees well with the underlying hypothesis that generalized hyperalgesia develops over time as a consequence of long-lasting pain [8].

Low PPT as a risk factor for future LBP

It might seem commonsensical that individuals with a low pain threshold are more likely to develop or report clinical pain. The current data, however, do not demonstrate an increased risk of future LBP in the group of ‘none-or-remitted LBP’ participants with the lowest PPTs. Thus, the current data suggest that the natural variability in constitutional pain sensitivity does not pose a distinct and separate risk factor for future LBP in itself, which corroborates the findings by Buchgreitz et al. [3] on headache sufferers.

It has been suggested that persistent LBP is part of a greater picture of co-morbidity in a “frail” sub-population albeit “the nature of the relationship between low back pain and other disorders is still unclear” [11]. Indeed, there is good evidence that LBP is associated with a range of other painful as well as non-painful co-morbid disorders [10, 21, 25]—generalized hyperalgesia following chronic pain offers at least a possible explanation of the nature of the relationship between such painful co-morbid disorders.

Arguably, PPT is a rather crude measure of pain sensitivity and other quantitative sensory tests such as temporal summation of pain or conditioned pain modulation (e.g. diffuse noxious inhibitory control) may yet prove to have predictive value for pain development and chronification in future research [1].

Weaknesses and caveats

The methodological limitations in the current study, primarily differences in procedures and instruments at baseline and 8-year follow-up, should temper the conclusion that PPTs change over time as a consequence of the development of chronic LBP, which can only be inferred from the present data. What is directly evident from the current study is the association of chronic LBP and generalized hyperalgesia and that low PPTs do not pose a risk for future LBP.

Conclusions

The present study demonstrates for the first time that even a very low PPT (10% percentile) does not constitute a separate and distinct risk factor for future LPB. Furthermore, an association between long-lasting LBP and both localized and generalized hyperalgesia was confirmed. Such associations were not found for recent LBP.

Conflict of interest None.

References

1. Arendt-Nielsen L, Yarnitsky D (2009) Experimental and clinical applications of quantitative sensory testing applied to skin, muscles and viscera. *J Pain* 10(6):556–572
2. Bakker EWP, Verhagen AP, van Trijffel E, Lucas C, Koes BW (2009) Spinal mechanical load as a risk factor for low back pain: a systematic review of prospective cohort studies. *Spine (Philadelphia, PA, 1976)* 34(8):E281–E293
3. Buchgreitz L, Lyngberg AC, Bendtsen L, Jensen R (2008) Increased pain sensitivity is not a risk factor but a consequence of frequent headache: a population-based follow-up study. *Pain* 137(3):623–630
4. Cherkin DC, Deyo RA, Street JH, Barlow W (1996) Predicting poor outcomes for back pain seen in primary care using patients’ own criteria. *Spine (Philadelphia, PA, 1976)* 21(24):2900–2907
5. Clauw D, Williams D, Lauerma W, Dahlman M, Aslami A, Nachemson A, Koblitz A, Wiesel S (1999) Pain sensitivity as a correlate of clinical status in individuals with chronic low back pain. *Spine* 24(19):2035–2041
6. Dagenais S, Caro J, Haldeman S (2008) A systematic review of low back pain cost of illness studies in the united states and internationally. *Spine J* 8(1):8–20
7. Giesecke T, Gracely R, Grant M, Nachemson A, Petzke F, Williams D, Clauw D (2004) Evidence of augmented central pain processing in idiopathic chronic low back pain. *Arthritis Rheum* 50(2):613–623
8. Graven-Nielsen T, Arendt-Nielsen L (2010) Assessment of mechanisms in localized and widespread musculoskeletal pain. *Nat Rev Rheumatol* 6(10):599–606
9. Hartvigsen J, Bakketeig LS, Leboeuf-Yde C, Engberg M, Lauritzen T (2001) The association between physical workload and low back pain clouded by the “healthy worker” effect: population-based cross-sectional and 5-year prospective questionnaire study. *Spine (Philadelphia, PA, 1976)* 26(16):1788–1792
10. Hestbaek L, Leboeuf-Yde C, Kyvik KO, Vach W, Russell MB, Skadhauge L, Svendsen A, Manniche C (2004) Comorbidity with low back pain: a cross-sectional population-based survey of 12- to 22-year-olds. *Spine (Philadelphia, PA, 1976)* 29(13):1483–1491
11. Hestbaek L, Leboeuf-Yde C, Manniche C (2003) Is low back pain part of a general health pattern or is it a separate and distinctive entity? A critical literature review of comorbidity with low back pain. *J Manipul Physiol Ther* 26(4):243–252
12. Hestbaek L, Leboeuf-Yde C, Manniche C (2003) Low back pain: what is the long-term course? A review of studies of general patient populations. *Eur Spine J* 12(2):149–165

13. Hoogendoorn WE, van Poppel MN, Bongers PM, Koes BW, Bouter LM (2000) Systematic review of psychosocial factors at work and private life as risk factors for back pain. *Spine (Philadelphia, PA, 1976)* 25(16):2114–2125
14. Hüppe A, Brockow T, Raspe H (2004) Chronic widespread pain and tender points in low back pain: a population-based study. *Z Rheumatol* 63(1):76–83
15. Jensen OK, Nielsen CV, Stengaard-Pedersen K (2010) Low back pain may be caused by disturbed pain regulation: a cross-sectional study in low back pain patients using tender point examination. *Eur J Pain* 14(5):514–522
16. Jensen TS, Kjaer P, Korsholm L, Bendix T, Sorensen JS, Manniche C, Leboeuf-Yde C (2010) Predictors of new vertebral endplate signal (modic) changes in the general population. *Eur Spine J* 19(1):129–135
17. Kjaer P, Leboeuf-Yde C, Korsholm L, Sorensen JS, Bendix T (2005) Magnetic resonance imaging and low back pain in adults: a diagnostic imaging study of 40-year-old men and women. *Spine* 30(10):1173–1180
18. Korff MV, Saunders K (1996) The course of back pain in primary care. *Spine (Philadelphia, PA, 1976)* 21(24):2833–2837
19. Kosek E, Ordeberg G (2000) Abnormalities of somatosensory perception in patients with painful osteoarthritis normalize following successful treatment. *Eur J Pain* 4(3):229–238
20. Linton SJ (2000) A review of psychological risk factors in back and neck pain. *Spine (Philadelphia, PA, 1976)* 25(9):1148–1156
21. McIntosh G, Hall H, Boyle C (2006) Contribution of nonspinal comorbidity to low back pain outcomes. *Clin J Pain* 22(9):765–769
22. O'Neill S, Manniche C, Graven-Nielsen T, Arendt-Nielsen L (2007) Generalized deep-tissue hyperalgesia in patients with chronic low-back pain. *Eur J Pain* 11(4):415–420
23. Pincus T, Burton AK, Vogel S, Field AP (2002) A systematic review of psychological factors as predictors of chronicity/disability in prospective cohorts of low back pain. *Spine (Philadelphia, PA, 1976)* 27(5):E109–E120
24. Rolke R, Baron R, Maier C, Tölle TR, Treede RD, Beyer A, Binder A, Birbaumer N, Birklein F, Bötefür IC, Braune S, Flor H, Häge V, Klug R, Landwehrmeyer GB, Magerl W, Maihöfner C, Rolko C, Schaub C, Scherens A, Sprenger T, Valet M, Wasserka B (2006) Quantitative sensory testing in the German research network on neuropathic pain (dfns): standardized protocol and reference values. *Pain* 123(3):231–243
25. Schneider S, Mohnen SM, Schiltenswolf M, Rau C (2007) Comorbidity of low back pain: representative outcomes of a national health study in the federal republic of Germany. *Eur J Pain* 11(4):387–397
26. Staud R, Nagel S, Robinson ME, Price DD (2009) Enhanced central pain processing of fibromyalgia patients is maintained by muscle afferent input: a randomized, double-blind, placebo-controlled study. *Pain* 145(1–2):96–104