Original

Pain Sensitivity and Reliability of the Posterior-Anterior Central Vertebral Pressure as a Provocative Test in Lumbar Pain

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Abstract

Background: The posterior-anterior central vertebral pressure (PACVP) is a manual diagnostic test for spinal pain; however, its sensitivity and reliability remain underexplored. This study evaluated the pain sensitivity and reliability of the PACVP as a provocative test in lumbar pain.

Method: This test-retest study involved 76 patients with lumbar pain attending outpatient physiotherapy in a tertiary hospital. Baseline pain-intensity was assessed using a visual analogue scale, while the lowest transcutaneous electrical nerve stimulation (TENS) threshold indicated TENS pain sensitivity. Two experienced physiotherapists assessed the patients' pain-intensity before and after PACVP at initial contact and after 48-hours. Differences in pain-intensity before and after PACVP were recorded as PACVP pain sensitivity. Descriptive statistics summarised data, while intra-class and inter-class correlation coefficients analysed the intra-rater and inter-rater reliabilities of PACVP, with precision measures. Pearson correlation coefficient analysed the relationship between variables at $p < 0.05$.

Results: Intra-rater reliabilities for PACVP were ICC = 0.93 with SEM (0.17), CV (11.9%) and ICC = 0.96 with SEM (0.15), CV (8.80%); while inter-rater reliability was ICC = 0.90 with SEM (0.22), CV (12.5%). Pain-intensity provoked by PACVP was negatively related ($p<0.05$) to pain sensitivity to TENS, whereas pain sensitivity to PACVP was positively related ($p<0.05$) to pain sensitivity to TENS.

Conclusion: The PACVP is a reliable test for lumbar pain. Pain-intensity provoked by PACVP is inversely related to pain sensitivity to TENS, while pain sensitivity to PACVP is directly related to pain sensitivity to TENS.

Keywords: Low back pain, Posterior-Anterior Central Vertebral Pressure, Pain Sensitivity, Reliability.

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Introduction

Low back pain (LBP) is a highly prevalent condition worldwide. It is the largest contributor to years lived with disability, according to the global burden of disease.[1] Low back pain is a major public health issue because it causes limitations in activity and work capacity, as well as inducing considerable economic and medical burdens on individuals, families, and governments.[2] The challenge of managing LBP effectively is compounded by the difficulty in accurately diagnosing its underlying cause.[3] Although there are various specific conditions (degenerative disc disease, spinal stenosis, myofascial pain syndromes) that result in LBP, about 90% of LBP is non-specific, meaning there is no identifiable or specific cause.[4,5] The heterogeneity of underlying causes makes it difficult for clinicians to identify the specific source of pain based on patient history and imaging alone.[6] To demystify the clinical diagnostics of LBP, it is broadly classified as mechanical when pain is associated with spinal structures such as bones, muscles, nerves, and surrounding soft tissues, and non-mechanical or systemic when pain is associated with systemic diseases like cauda equina syndrome, malignancy, fracture, infection, progressive neurological loss, urinary incontinence, cancer, recent invasive spinal procedures, among others.[4,6,7]

Consequently, experts involved in the management of LBP frequently use physical examination techniques as provocative tests to localise the source of mechanical LBP by reproducing symptoms through specific manoeuvres. The posterior-anterior central vertebral pressure (PACVP) is one such technique and was classically described by George Maitland in his book *Vertebral Manipulation*.[8-10] It is used in manual therapy to detect pathology in the spinal column and is applied by superimposing the thumbs on the spinous process of a chosen vertebra with firm, downward but gentle pressure while the patient is lying prone.[8,11,12] The PACVP is employed as a test in assessment and treatment modality in spinal pain.[8,13,14] It is used as a treatment when applied in grades of oscillations on the spine, and as such, it is also called posterior-anterior mobilisation or vertical oscillatory pressure, while it is used as a test when applied once on the spine and referred to as vertical compression or digital postero-anterior pressure of the spine.[15,16] Additionally, the PACVP is a procedure for diagnosing spinal lesions and is used to reproduce pain from degenerating spinal vertebrae and pain arising from nerve compression.[11,16]

The PACVP is relatively easy to perform, low-cost, and can be used in various clinical settings, unlike expensive technological devices like the pressure algometer for spinal pain. However, despite its clinical utility, there is little literature regarding its pain sensitivity, vis-à-vis its ability to repeatedly reproduce patients' pain from inducing spinal segments.

A few studies have assessed the reliability of PACVP in evaluating spinal stiffness and mobility.[8,11] The study conducted by Onigbinde and colleagues[11] quantified the pressure applied during PACVP by comparing the spinal digital pressure with pressure on a sphygmomanometer and body weight scale. Studies examining the primary purpose of PACVP to reproduce pain from a spinal vertebra are limited. On the other hand, the pressure algometer has evolved in recent times as a means of detecting and quantifying spinal pain.[17] The pressure algometer measures the pain pressure threshold by quantifying the force value of tissue tenderness that occurs at the minimum transition point when the applied pressure is sensed as pain,[17] an ability not attainable with PACVP, a commonly used and cost-effective manual technique used by manual therapists and physiotherapists.

Meanwhile, electrical stimulation is one of the means traditionally used as a standardised procedure in research and clinical practice to measure pain thresholds.[18] This procedure involves gradually increasing the intensity of electrical stimulation until the subject reports the sensation as painful, thereby establishing the pain threshold.[18] The pain threshold is the point at which a sensation first becomes painful.[19] It is synonymous with pain sensitivity in the literature, which is defined as "the least experience of pain that a subject can recognise".[20] The pain experienced in a pathological vertebra from PACVP may be sensitised in the same way a painful stimulus is experienced when electrical stimulation is applied. It is believed that light touching of the skin is capable of evoking an intense pain sensation as mechanical allodynia in neuropathic and inflammatory pain conditions.[21] Pain triggered by light touch may be due to altered central processing of Aβ low-threshold mechanoreceptor input or activation of sensitised peripheral nociceptors.[21]

In addition, DeJesus et al.[22] reported that acute experimental pain can be induced with mechanical

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stimulation, movement, ischaemia, nociceptive reflex, cold, heat, or electrical stimulation. Thus, given that PACVP is a manual test that involves the use of mechanical pressure, it is possible to quantify its pain sensitivity, that is, its pain threshold or the point at which the central processing of Aβ low-threshold mechanoreceptor input would be altered or triggered by determining the difference in pain intensity before and after its application, as well as relating it to the pain sensitivity from a gold standard such as a known electrical stimulation modality. Hence, this study was intended to fill the gap in the literature regarding pain sensitivity and reliability of PACVP as a provocative test for lumbar pain. Therefore, this study investigated the pain sensitivity and reliability of PACVP as a provocative test for lumbar pain.

Methodology

This study employed a test-retest design conducted among patients with LBP who were consecutively recruited from the orthopaedic outpatient clinic of the Department of Physiotherapy at a University Teaching Hospital. Two licensed physiotherapists, each with a minimum of five years of experience in performing PACVP in outpatient orthopaedic physiotherapy, were purposively selected. Patients were included in the study if they were: aged 18 years and above, had no complaints of radiating pain, no history of spinal surgery, had undergone x-rays of the lumbosacral spine with no report of spondylolisthesis or spinal malalignment, were willing to discontinue pain-relieving medications 48 hours prior to participation and 48 hours after the first day of contact. The exclusion criteria were patients who were pregnant or had obesity (Body Mass Index (BMI) ≥ 30 and Waist Circumference (WC) greater than 1.02m for men and 0.88m for women). Ethical approval was sought and obtained from the Health Research and Ethics Committee of the University Teaching Hospital (ADM/E 22/A/VOL.VII/14865432028), while informed consent was obtained from the patients.

The sample size formula for dichotomous sample with a finite population size was used, n = $(Z^2 \times p(1-p))/(E^2 + ((Z^2 \times p(1-p))/N))$;[23] where Z = the standard normal distribution reflecting the confidence level that would be used and it is usually set to Z = 1.96 for 95%, E = desired margin of error, set at 5% (0.05), p = approximate anticipated proportion of successes in the population and it usually ranges between 0-1. If unknown, the value 0.5 is used to estimate the sample size, N = population size (number of patients being managed for LBP in the orthopaedic out-patient Department of the University Teaching Hospital, in this case was 95). n = $(〖1.96〗^2 \times 0.5(1-0.5))/(〖0.05〗^2 + ((〖1.96〗^2 \times 0.5(1-0.5))/95))$, n = 76.16=76 participants. After patients provided informed consent, a pre-test assessment was conducted by one of the authors. This assessment involved collecting demographic data on age and gender, along with patients' medical history, which focused on the duration and nature of the LBP. X-ray reports were collected to determine if patients met the inclusion criteria, after which they were enlisted in the study. Anthropometric parameters of height, weight, BMI, and WC were then measured. Patients' baseline pain intensity was assessed using a well validated tool - the Visual Analogue Scale (VAS)[24] and recorded. The VAS is a 10cm line drawn on a plain sheet, with one end indicating 'no pain' and the other end indicating 'worst imaginable pain'. Patients were required to mark a vertical line on the scale to indicate their level of pain intensity. Additionally, patients' pain sensitivity to electrical stimulation was assessed using TENS and recorded. The PACVP was performed by the two physiotherapists, who were stationed in separate treatment rooms for the sole purpose of examining patients' pain intensity induced by PACVP using the VAS on the same day and after 48 hours. The two physiotherapists were instructed to assess patients only for their pain intensity using the VAS.

Measurement of anthropometric parameters: To assess height, the patients were instructed to remove their foot and headwear a nd stand on the stadiometer with their eyes forward, feet slightly apart, and heels touching the stadiometer.[25] The middle of their shoulders, buttocks, and the back of their head also touched the stadiometer. The examiner gently lowered the sliding part of the stadiometer to touch the participant's hair. The height was read to the nearest 0.1m and recorded.

A calibrated weighing scale was used to assess the patients' weight. The scale was reset to zero before use. The patients were also instructed to remove their footwear, heavy jewellery, or any items from their pockets, such as money or keys, and then stand on the weighing scale with their weight evenly distributed and

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their arms hanging loosely at their sides.[25] The examiner waited for the scale to stop oscillating before recording the results to the nearest 0.1Kg.
The BMI of each patient was calculated as the ratio of weight to height squared, to the nearest 0.1Kg/m².

To assess the WC of each patient, the examiner located the bony landmarks of the lowest rib and the iliac crest at the level of the mid-axillary line.[25] The tape measure was placed in a horizontal plane around the abdomen, at the level just above the uppermost lateral border of the iliac crest, just below the lowest rib, and midway between both sites.[25] Special attention was given to ensure the tape was parallel to the floor. The measurement was made at the end of normal expiration, with the tape adjacent to but not compressing the skin, and the participant standing erect.

Measurement of pain sensitivity using TENS: The protocol for TENS was adequately explained with specific instructions to the patients. Patients lay prone on the couch with their heads resting on a pillow (Figure 1). The skin over the lumbar spine was cleansed with alcohol swabs.[26] The examiner then placed two self-adhesive surface electrodes of the TENS device on the spinous processes of L1-L5, as indicated by the location of the patients' pain. Stimulation parameters were set to a frequency of 250 Hz, a current intensity of 80 mA, and a maximum intensity of 8 mA. The examiner instructed the patients to report their experience of pain sensation as the intensity of the TENS was gradually increased. The level of intensity at which the patient reported pain was recorded as the patient's pain sensitivity to TENS.

Figure 1: Application of transcutaneous electrical nerve stimulation (TENS) to the lumbar spine

Measurement of pain sensitivity using posterior anterior central vertebral pressure: The patient lay in a prone position with their back exposed. A marker was used to mark the spinous processes of the L1-L5 lumbar vertebrae. The examiner palpated along the lumbar spine and applied firm pressure with the juxtaposed fingertips at the specific spinal segments (Figure 2).[11] The pressure was applied gradually and maintained for a few seconds at each spinal level to reproduce the patient's pain. The patients were asked to indicate the pain intensity on a VAS sheet immediately after the pressure application. The difference between the patients' VAS scores after PACVP and their baseline VAS scores was recorded as the patients' pain sensitivity to PACVP.

Fig. 2: Physiotherapist performing PAVP on a patient.

Data analysis: Data were analysed using the Statistical Package for the Social Sciences (IBM SPSS version 26). All data were summarised using descriptive statistics, including mean, standard deviation (SD), frequency, and percentages. Intra-class correlation coefficient (ICC, two-way random with absolute agreement) and inter-class correlation coefficient (ICC, two-way mixed with absolute agreement), with 95% confidence intervals, were used to test intra-rater and inter-rater reliability of PACVP, respectively. The ICC score interpretation provided by Koo and Li was applied as follows: > 0.9 = excellent, 0.75–0.9 = good, 0.5–0.74 = moderate, < 0.50 = poor.[27] The standard error of measurement (SEM) (calculated as SEM = SD$\sqrt{}$1-ICC) and coefficient of variation (CV) were used to determine the precision of PACVP reliability. Pearson correlation coefficient was used to determine the relationship between patients' pain sensitivity to TENS and pain intensity or sensitivity to PACVP at $p < 0.05$.

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Results

Out of the 76 patients that participated in the study, 46 (60.5%) were females, 51(67.1%) had pain at the L4 spinal level, 70 (92.1%) experienced symptoms of lumbar pain for 3 months or more and 50(65.8%) of the patients reported using pain medications (Table 1). The mean baseline pain intensity was 4.46±1.17, while the mean pain sensitivity to TENS was 4.40±0.56 mA (Table 1).

Table 1: Participants demographic and clinical characteristics (n=76)

Variable	Mean ± SD	Min	Max
Age	48.42 ± 15.28	22.00	82.00
Baseline pain intensity	4.46 ± 1.17	2.50	7.50
Pain sensitivity to TENS (mA)	4.40 ± 0.56	2.00	4.40
	Frequency (n)	**Percentages (%)**	
Sex			
Female	46	60.5	
Male	30	39.5	
Location of Pain			
L3	6	7.9	
L4	51	67.1	
L5	19	25.0	
Pain Duration			
1 – 3 months	6	7.9	
3 – 12 months	26	34.2	
≥ 12 months	44	57.9	
Use of Pain Medication			
No	26	34.2	
Yes	50	65.8	

Key: Min = Minimum, Max = Maximum

The anthropometric characteristics are as shown in Table 2. mean values of the patients' age, height, weight, BMI, and WC were 48.42±15.28 years, 1.66±0.06 m, 68.71±6.17 Kg, 24.85±1.98 kg/m², and 19.4±0.76 kg/m², respectively (Table 2).

Table 2: Anthropometric status of participants (n=76)

Variable	Mean ± SD	Minimum	Maximum
Height (m)	1.66 ± 0.06	1.55	1.83
Weight (Kg)	68.71 ± 6.17	54.00	82.00
BMI (Kg/m²)	24.85 ± 1.98	19.40	29.7
WC (m)	0.76 ± 0.43	0.67	0.86

Key: BMI = Body mass index, WC = Waist circumference, SD = Standard deviation

The mean pain intensity produced after PACVP by the examiners on the first day of application and after 48 hours is presented in Table 3.

Table 3: Patients' pain intensity reproduced by PACVP (n=76)

Variable	Pain intensity on 1st day Mean ± SD	Pain intensity after 48 hours Mean ± SD
Examiner 1	8.21 ± 0.93	8.17 ± 0.88
Examiner 2	8.17 ± 0.78	8.15 ± 0.74

Key: SD = Standard deviation, PACVP = Posterior anterior central vertebral pressure

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The findings revealed intra-rater reliability scores of ICC = 0.93 and ICC = 0.96 for the first and second examiners, with measurement errors of SEM = 0.17, CV = 11.9% and SEM = 0.15, CV = 8.80%, respectively (Table 4).

Table 4: Intra-rater reliability of PACVP (n=76)

Variable	Mean ± SD[1]	ICC	95% Confidence Interval		SEM	CV (%)	p-value
			LB	UB			
Examiner 1	3.73 ± 0.64	0.93	0.89	0.96	0.17	11.0	0.000
Examiner 2	3.73 ±0.64	0.96	0.94	0.98	0.15	8.8	0.000

Key: 1 = inter-item means and standard deviation; PACVP = posterior anterior central vertebral pressure; ICC = intra-class correlation coefficient; SD = standard deviation; SEM = standard error of measurement; CV = coefficient of variation; LB = lower bound; UB = upper bound.

The study revealed good inter-rater reliability of PACVP (ICC = 0.90) with low error (SEM = 0.22, CV = 11.9%) in measurement between the examiners on the first day of application and excellent inter-rater reliability (ICC = 0.91) with low error (SEM = 0.22, CV = 12.5%) in measurement after 48 hours (Table 5).

Table 5: Inter-rater reliability of PACVP (n=76)

Variable	Mean ± SD[1]	ICC	95% Confidence Interval		SEM	CV (%)	p-value
			LB	UB			
PACVP							
Assessment[a]	3.73 ± 0.68	0.90	0.84	0.94	0.22	11.9	0.000
Assessment[b]	3.71 ± 0.73	0.91	0.86	0.94	0.22	12.5	0.000

Key: 1 = inter-item means and standard deviation; PACVP = posterior anterior central vertebral pressure; ICC = inter-class correlation coefficient; SD = standard deviation; SEM = standard error of measurement; CV = coefficient of variation; LB = lower bound; UB = upper bound; a = first assessments by the examiners; b = second assessment by the examiners after 48 hours.

Patients' pain intensity provoked by PACVP is negatively related to patients' pain sensitivity to TENS (Table 6). However, patients' pain sensitivity to PACVP is positively related to patients' pain sensitivity to TENS (Table 6).

Table 6: Relationship between participants pain sensitivity to TENS and pain intensity or sensitivity induced by PACVP (N=76)

Variable	Pain Sensitivity to TENS (r)	p-value
Pain intensity induced by PACVP		
Examiner 1	-0.46	0.000***
Examiner 2	-0.43	0.000***
Pain sensitivity to PACVP		
Examiner 1[a]	0.15	0.201
Examiner 1[b]	0.24	0.037***
Examiner 2[a]	0.12	0.323
Examiner 2[b]	0.27	0.020***

TENS = transcutaneous electrical nerve stimulation; PACVP = posterior anterior central vertebral pressure; *** = p is significantly different.

Discussion

This study evaluated the pain sensitivity and reliability of the PACVP test as a provocative diagnostic tool for lumbar spinal pain. The findings provide evidence supporting the utility of PACVP in clinical settings, particularly in reproducing pain from spinal segments and therefore, corroborates the study's results with existing literature to contextualise its implications for clinical practice and research.

The study revealed a high prevalence of chronic lumbar spinal pain, with the majority of the participants reporting symptoms lasting over 3 months. Chronic pain is often associated with central sensitisation, a condition where the nervous system amplifies pain signals, leading to heightened pain perception even in the absence of significant peripheral pathology.[28] The finding of pain at the L4 and L5 spinal levels in most of the participants aligns with Fritz and colleagues' report that these segments are biomechanically prone to degeneration and

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stress due to their role in load transfer during movement.[29] This ability of the PACVP to reproduce pain by eliciting segmental tenderness is particularly valuable, as it aids in identifying specific spinal segments that may benefit from targeted intervention.[29]

In this study, respondents' anthropometric variables of BMI and WC indicated that the participants were within the normal range for both BMI and WC. The observed normal BMI and WC of respondents suggest that the participants were not obese, and therefore, were not influenced by obesity on lumbar spine biomechanics, as reported by Shiri et al.[30] Thus, the absence of extreme BMI values in this study minimised potential confounding effects, supporting the reliability of the PACVP results in this cohort. However, the literature emphasises the importance of considering other factors, such as muscle strength and spinal curvature, which were not directly measured in this study but may influence test outcomes.[31]

The PACVP test demonstrated good inter-rater reliability with low error in measurement between the examiners on the first day of application and excellent inter-rater reliability with low error in measurement after 48 hours. Notably, this finding of this study regarding the excellent intra-rater reliability of PACVP, with a very low standard error of measurement and coefficient of variation, highlights the consistency of PACVP's ability to reproduce pain from a painful spinal segment. This reliability validates the use of PACVP for repeated assessments, emphasising its utility in longitudinal pain monitoring. Additionally, the finding that the inter-rater reliability of PACVP demonstrated good reliability, with a very low standard error of measurement and coefficient of variation implies that, regardless of individual differences, PACVP is a useful clinical tool for reproducing pain from an inducing spinal segment. Furthermore, these findings of excellent intra-rater reliability and good inter-rater reliability of PACVP with very low standard error of measurement and coefficient of variation suggest that variability in the application of the PACVP technique is minimal, unlike the report of variability in pressure application of some manual palpation techniques often seen among clinicians.[32] However, the reliability scores for PACVP on patients' pain intensity obtained in this present study is higher than the reliability scores reported by Maher Adams[8]. Maher and Adams reported a reliability score range of 0.54% to 0.85%, while this study revealed a reliability score range of 0.84% to 0.94%. One major difference between this study and that of Maher and Adams is their use of numerical pain rating scale to assess their participants' pain intensity, while this study used the VAS to assess participants' pain intensity. The VAS has been found to have high test-retest reliability and repeatability, and is said to be sensitive to variables that increase or decrease pain, and has the capacity to measure multiple dimensions of pain.[24] Moreover, the reliability score range obtained by this study is consistent with the reliability score range of 0.75% to 0.99% reported by Bhattacharyya et al[33] for pressure pain threshold, which is assessed by a pressure algometer as pain in individuals with LBP. Though, it is easier and cheaper for clinicians to reproduce pain from an inducing segment with PACVP because of its low cost and manual approach than using the pressure algometer to do the same.

Another contribution of this study was that a significant inverse relationship was observed between patients' pain sensitivity to TENS and pain intensity provoked by PACVP. This implies that as patients' pain sensitivity to TENS increases, pain intensity provoked by PACVP decreases, and vice versa. This is supported by the findings of this study, which showed that the mean values of patients' pain sensitivity to TENS were similar to the mean values of pain sensitivity to PACVP. In contrast, the mean values of patients' pain intensity to PACVP were higher, suggesting greater pain intensity provoked by PACVP than pain sensitivity to TENS. High pain intensity to PACVP is indicative of patients' high responsiveness to mechanical stimuli. Sang et al[21] demonstrated that a current of 2mA or higher is required to activate Aδ and C nociceptors in apparently healthy individuals. The finding of similar average pain sensitivity to TENS and PACVP is consistent with previous report suggesting that chronic pain is associated with reduced pain thresholds due to peripheral and central sensitisation.[34]

Furthermore, the finding of a direct relationship between patients' pain sensitivity to TENS and PACVP underscored the diagnostic potential of the PACVP, as it relies on the same principle of eliciting pain responses through localized pressure. While pain sensitivity can be measured during TENS applications, the pain sensitivity due to PACVP can be ascertained by considering the

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patients' report of pain intensity before and after the application of PACVP. This makes PACVP particularly useful in clinical settings where advanced diagnostic tools like pressure algometers are unavailable. The PACVP is low-cost, and its ease of application makes it an attractive option for initial assessments, especially in resource-limited settings.

Overall, this study recommends the PACVP as an assessment tool for reproducing pain from a painful lumbar spine. However, enhanced training may be required for physiotherapists and manual therapists on the standardized procedure for PACVP in clinical practice. This is necessary because physiotherapists as healthcare professionals are trained in the prevention, diagnosis, and treatment of physical impairments, disabilities, and pain through exercise, modalities, manual therapy, and education, while manual therapists are specialists in physiotherapy or other healthcare professions such as osteopathy or chiropractic that uses hand maneuver or techniques in the assessment and treatment of physical impairments and pain. The findings of this study have several implications for clinical practice. First, the PACVP's sensitivity to pain-inducing spinal segments highlights its potential as a cost-effective diagnostic tool for lumbar spinal pain. Secondly, the correlation between the pain sensitivity of PACVP and TENS supports the integration of subjective and objective measures to improve diagnostic accuracyy.

Conclusion

The PACVP is a reliable test for lumbar spinal pain. The findings of this study demonstrated that the PACVP has excellent intra-rater reliability and good inter-rater reliability in reproducing pain from a painful lumbar spine. Additionally, pain intensity provoked by PACVP is inversely related to pain sensitivity to TENS. However, pain sensitivity to PACVP is directly related to pain sensitivity to TENS.

Conflicts of interest declaration: The authors of this study declare no conflict of interest whatsoever.

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Ethical conformity statement: Ethical approval was sought and obtained from the Health Research and Ethics Committee of a University Teaching Hospital (ADM/E 22/A/VOL.VII/14865432028), while informed consent was obtained from the patients.

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