Research Square

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Comparative Assessment and Correlation of Pain Intensity Using the Visual Analogue Scale and Digital Pressure Sensor Machine in Adults with Chronic Non-Specific Low Back Pain

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Abstract

Background

Pain assessment remains controversial due to the lack of standardized methods, with subjective tools like the Visual Analogue Scale (VAS) limited in accuracy, thereby prompting the emergence of objective approaches such as the Digital Pressure Sensor Machine (DPSM). This study assessed pain intensity using VAS and DPSM, and compared and correlated pain intensity scores obtained via the VAS and the DPSM in adults with CNSBP.

Methods

In this cross-sectional study, forty patients with chronic low back pain underwent pain assessment using DPSM and VAS, with tolerance evaluated via the Pain Pressure Threshold Scale; data were analysed at $\alpha = 0.05$ following ethical approval and informed consent.

Results

Participants had a mean age of 38.23 years. Average pain scores were 4.13 on the VAS and 63.90 N on the DPSM. Wilcoxon sign rank revealed significant differences in pain intensity across instruments ($W = 780$, $p < 0.001$, $rB = 1.00$). Correlation analyses showed strong agreement between DPSM and VAS ($p < 0.001$, $r = 0.76$, Fisher's $z = 0.999$) and moderate correlations between DPSM and PPTS ($p < 0.001$,$r = 0.56$, Fisher's $z = 0.6313$).

Conclusions

Both VAS and DPSM can be used to assess pain in patients with chronic back pain. CNSBP can be assessed objectively with the Digital Pressure Sensor Machine (DPSM). Additionally, DPSM is strongly correlated with VAS.

Introduction

Studies have shown that pain assessment and measurement have remained a usual process in patient management (1). However, there is still no standard pain assessment due to the multidimensional nature of pain perception and threshold (2). Studies have shown that subjective means of pain assessment are well known among clinicians (3) (4)while objective pain assessment is emerging yet hampered by accuracy in documentation (5,6). Accurate assessment requires attention to pain location, intensity, cultural influences, and functional consequences, thereby guiding tailored interventions for improved patient care (7,8).

Pain is multidimensional; therefore, assessment must include the intensity, location, duration, and description(4). Pain is inherently subjective and remains one of the most common reasons individuals seek healthcare, particularly physiotherapy services (9). To improve diagnostic precision, recent research has focused on objective methods for measuring pain. Specifically, investigators have utilized pressure algometers and digital sensors to quantify pain intensity (10,11).

Healthcare pain sensor technology aims to convert the subjective experience of pain into quantifiable, real-time physiological data(12). These tools are highly useful for continuous monitoring, tracking chronic conditions, or evaluating non-verbal, sedated, and critically ill patients (11). Pressure algometry and modern sensory technologies represent the clinical gold standards for objectively quantifying physical tissue tenderness and mechanical pain thresholds(13,14). Unlike a purely subjective visual analogue scale, an algometer introduces an exact, mathematically controllable physical force gauge to map out underlying hyperalgesia and central sensitization (15).

In objective clinical pain assessment, clinicians and researchers strongly prefer an algometer over traditional manual evaluation techniques(16). However, applying vertical oscillatory pressure (VOP) (17) requires manual palpation combined with digital force to assess pain symptoms. This dependency increases the clinical preference for digital pressure sensors over standard algometers during VOP application(17).

Research indicates that manual pressure palpation yields the highest reliability for pain assessment, outperforming both motion and soft-tissue palpation (18). As a foundational component of standard physiotherapy examinations, manual pressure palpation is routinely utilized to identify localized tender points and patient discomfort (19). Consequently, the emergence of the Digital Pressure Sensor Machine (DPSM) has significantly improved objective pain assessment (17). Furthermore, recent studies have demonstrated the clinical utility of digital pressure sensors during manual palpation, establishing their effectiveness in quantifying mechanical pain thresholds (20).

Subjective pain assessment techniques are widely employed in clinical practice, yet they remain limited by issues of objectivity (5). Consequently, contemporary research emphasises the necessity of objective pain evaluation modalities, leading to the introduction of innovative tools like the Digital Pressure Sensor Machine (DPSM). Prior literature confirms that the Pain Pressure Threshold Scale (PPTS) effectively categorizes mechanical pain severity in low back pain cohorts and correlates strongly with subjective verbal scales (21). Advancing this paradigm, specialised diagnostic platforms like the DPSM provide superior measurement reproducibility, ultimately optimizing clinical outcomes and patient care (22).

Therefore, this study evaluated and compared pain measurements using the Digital Pressure Sensor Machine (DPSM), the Pain Pressure Threshold Scale (PPTS), and the Visual Analogue Scale (VAS), and further examined the relationship between pain scores obtained with DPSM and VAS

Methods

Forty patients with chronic LBP were purposively recruited for this cross-sectional observational study. Ethical approval (UNIMEDTH/ERC/026/020) and Informed consent were obtained. Participants' pain intensity was assessed with both DPSM and VAS during digital pressure on the symptomatic vertebrae of patients with chronic LBP after ethical approval and informed consent were secured. Pain tolerance of each patient was assessed with the Pain Pressure Threshold Scale to pick the minimum DP force magnitude in Newtons.

Digital Pressure Sensor Machine (DPSM): This is a Nigerian-made DPSM (Fig. 1) (17). The sensor was attached to the thumb pad of each Physiotherapist before the digital pressure phase of VOP (Fig. 1). Digital pressure magnitude was taken during the digital pressure phase of VOP, with feedback for the minimum threshold measured with the pressure pain threshold scale (PPTs) (Fig. 2), which corresponded with the display of magnitude of force in Newtons on the sensor machineduring Digital pressure phase.

Visual Analogue Scale: The Visual Analogue Scale (VAS) is a psychometric instrument(intraclass correlation coefficient (ICC) of 0.97 and validity ranging from 0.68 to 0.89) (23). It typically consists of a 100 mm straight line with descriptive anchors at each end representing the extremes of the sensation (for example, "no pain" at one end and "the most severe pain imaginable" at the other). Respondents indicate their experience by marking a point on the line, and the distance from the lower anchor is measured and recorded as a continuous variable (Koo & Yang, 2025). Descriptive and inferential statistics with JASP version 0.97.01 were used to analyse this study. Alpha level of significance was set at 0.05.

Figure I: Digital Pressure Sensor Machine.

Figure II: Application of digital pressure on the symptomatic L4 vertebra with the use of a digital pressure sensor machine: flexi sensor attached to the right thumb pad of the researcher.

Results

Descriptive statistics of the participants

Table I presents the descriptive statistics and normality of the data. Pain outcomes were recorded as 4.13 ± 1.92 on the Visual Analogue Scale and 63.90 ± 49.2 with the Digital Pressure Sensor Machine. The coefficient of variation (CV%) exceeded 10%, indicating moderate variability. Shapiro–Wilk testing revealed a non-normal distribution ($p < 0.05$), thereby justifying the application of the non-parametric Wilcoxon signed-rank test.

Within-group comparison of pain intensity measured with DPSM and VAS was conducted using the Wilcoxon signed-rank test.

Table II presents the within-group mean comparison of pain scores assessed with DPSM and VAS, analysed using the Wilcoxon signed-rank test, which revealed significant differences in pain intensity between the instruments and indicated a large effect (W = 780, p < 0.001, rB = 1.00).

Relationships between pain intensity instruments were assessed using Pearson's correlation coefficients.

The relationships between pain outcomes across instruments were examined using Pearson's correlation coefficients. Table III presents the results, showing significant relationship between the Digital Pressure Sensor Machine (DPSM) and the Visual Analogue Scale (VAS; r = 0.76, p < .001, Fisher's z = 0.99), DPSM and the Pain Pressure Threshold Scale (PPTS; r = 0.56, p < .001, z = 0.63), and VAS and PPTS (r = 0.61, p < .001, z = 0.84). A particularly strong relationship was observed between the DPSM and VAS.

Table I: Descriptive statistics of the participants

Mean (arithmetic)	**VAS**	**DPSM**	**Age**
	4.128	**63.90**	**38.23**
Std. Deviation	1.922	44.26	12.62
Coefficient of variation	0.4656	0.6927	0.3301
Shapiro-Wilk	0.9260	0.89	0.9323
P-value of Shapiro-Wilk	0.013	0.002	0.021
Minimum	1.000	8.000	20.00
Maximum	7.000	140.0	60.00

Key:

VAS: Visual Analogue Scale

DPSM: Digital Pressure Sensor Machine

Table II: Within-group comparison of pain intensity assessed with DPSM and VAS

Measure 1		**Measure 2**	**W**	**z**	**df**	**p**	**HLE**	**rB**	**SE Rank-rB**
DPSM	-	VAS	780.0	5.442		< .001	58.00	1.000	0.1817
Key : HLE: Hodges-Lehmann Estimate									
rB: Rank-Biserial Correlation									

Table III: Relationships between pain intensity instruments were assessed using Pearson's correlation coefficients				
Variable		VAS	DPSM	PPTS
VAS	Pearson's r	—		
	p-value	—		
	Effect size (Fisher's z)	—		
	SE Effect size	—		
DPSM	Pearson's r	0.7615	—	
	p-value	< .001	—	
	Effect size (Fisher's z)	0.9998	—	
	SE Effect size	0.1667	—	
PPTS	Pearson's r	0.6863	0.5589	—
	p-value	< .001	< .001	—
	Effect size (Fisher's z)	0.8410	0.6313	—
	SE Effect size	0.1667	0.1667	—

Key:

VAS: Visual Analogue Scale

DPSM: Digital Pressure Sensor Machine

PPTs: Pain Pressure Threshold Scale

Discussion

This study compared pain intensity measurements obtained using a Digital Pressure Sensor Machine (DPSM) and the Visual Analogue Scale (VAS). It determined the relationship between the DPSM and the VAS.

The results from this study showed that the Digital Pressure Sensor Machine (DPSM) demonstrates a stronger capacity for detecting pain compared to the Visual Analogue Scale (VAS). While the VAS relies on subjective self-reporting (24) which can be influenced by individual perception and variability (25), the DPSM provides objective, quantifiable measurements of applied pressure, thereby reducing bias and enhancing precision in pain detection (20). The observed superiority of DPSM highlights its potential as a more sensitive instrument for capturing subtle changes in pain thresholds, offering greater reliability in both clinical and research contexts (26). This finding underscores the importance of integrating

objective sensor-based technologies into pain assessment protocols, as they may complement or even surpass traditional self-report measures in accurately reflecting pain sensitivity (27).

This study indicates that the Digital Pressure Sensor Machine (DPSM) demonstrated a stronger relationship with the Visual Analogue Scale (VAS) in patient measurements and pain detection than the Pain Pressure Threshold Scale. This suggests that the two instruments complement each other in capturing pain outcomes (28). While the VAS provides a subjective self-report of pain intensity (23), the DPSM offers objective quantification of applied pressure (29). The significant correlation between them reinforces the validity of DPSM as a reliable tool. This stronger association implies that DPSM not only aligns well with patients' perceived pain levels but also enhances the accuracy of detection by reducing reliance on subjective interpretation alone. Consequently, the integration of DPSM alongside VAS could improve the robustness of pain assessment protocols, ensuring that both patient-reported experiences and objective measurements are considered in clinical and research settings (30).

Conclusion

The findings of this study indicate that the Digital Pressure Sensor Machine (DPSM) is effective in detecting pain intensity. Its performance shows strong comparability with the Visual Analogue Scale (VAS), demonstrating a robust relationship with VAS outcomes.

Declarations

Human ethics and consent to participate: Approval for this study was obtained from the University of Medical Sciences Teaching Hospital Ethics Committee (Ethical registration number: UNIMEDTH/ERC/026/020), and the study complied with the guidelines outlined in the Declaration of Helsinki. All participants provided informed consent before completing the questionnaire. Participant data were stored in password-protected electronic files and locked cabinets accessible only to the research team, and all analyses were conducted using de-identified datasets to protect confidentiality further.

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Author Contribution

Taofik Afolabi: study conceptualisation, study administration, manuscript preparationAanuoluwapo Afolabi: Data analysisPeace Akanbi: Data collection

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Figures

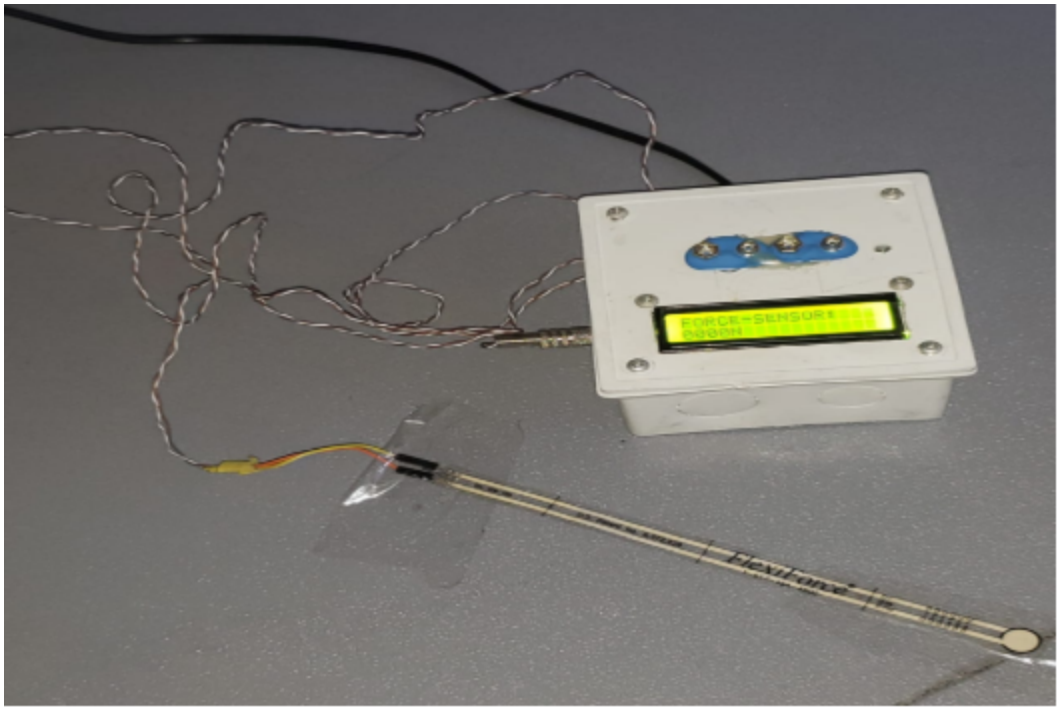

Figure 1

Digital Pressure Sensor Machine.



Figure 2

Application of digital pressure on the symptomatic L4 vertebra with the use of a digital pressure sensor machine: flexi sensor attached to the right thumb pad of the researcher.