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Visualizing low back pain: analysis of facial expressions for objective measurement through image processing.

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1 INTRODUCTION

Detailed coding of facial activity provides a mechanism for understanding the biological, behavioral, cognitive and social processes of pain that self-report measures do not address[1]. Facial activity appears to be the most consistent expression of pain, mediated by specific neurological circuits[2]. Studies have shown that facial expressions of pain are consistent and universal across different cultures, reflecting automatic responses to nociceptive stimuli[3, 4]. Thus, the proposed objective was to develop software to objectively measure experimentally induced acute low back pain during a submaximal strength test, using facial activity coding to capture biological and behavioral processes that complement traditional self-reporting methods.

2 MATERIALS AND METHODS

2.1 SOFTWARE

Software has been developed to detect changes in facial expression in the context of experimentally induced acute low back pain. face detection in each frame is carried out using the haar cascade algorithm[5]. in the facial region, histograms are assembled and concatenated using local binary pattern histograms (LBPH)[6]. the system is trained with a reference video containing neutral facial expressions and evaluates a second video in which the expressions are analyzed frame by frame. The program measures and displays the difference between each frame of the second video and the ‘average’ face of the training frames, calculating average module differences between the histograms of the current frame and the average training histogram.

2.2 EXPERIMENTALLY INDUCED ACUTE LOW BACK PAIN

The study included 15 healthy volunteers (30.6 ± 6.4 years; 72.4 ± 10.69 kg; 171.53 ± 6.45 cm) who received injections of hypertonic saline solution (6.0%) to induce low back pain. They were assessed in two conditions: without pain and during acute low back pain, during a spinal extension task in the prone position, with a dynamometer measuring submaximal force positioned on the midline of the scapulae. Facial expressions were captured by a GoPro camera and the videos were analyzed using the OpenCV library in the Python programming language. The force data was processed using MATLAB® software. Significant differences between conditions were assessed using descriptive statistics and the Wilcoxon test.

3.0 RESULTS

Table 1 presents the main results, highlighting the significant differences between the pain and no-pain conditions, and providing a detailed analysis of the behavior of facial expressions and muscle strength in response to experimentally induced acute low back pain. The software demonstrated a robust ability to capture facial variations in both conditions (figure 1), evidencing its effectiveness in consistently identifying facial changes associated with the pain state and its enhanced sensitivity to detect facial responses in the context of pain.

Table 1: Descriptive data from software measurements during pain and in the absence of pain.

	During Pain	No Pain	*p*
Facial expression	10.04 (4.14)	5.47 (2.59)	<0.001
CV%	41.21	47.34	
SEM %	2.53	1.58	
Force	1.96 (0.29)	2.02 (0.31)	<0.001

Legend: values are expressed as mean (standard deviation), coefficient of variation (CV) expressed as percentages, Standard Error of the Mean (SEM), p value of the difference in facial expression between those with pain and those without, and force, in the same time window.

Figure 1: difference in facial expression without and during induced acute low back pain Legend: a) no pain, b) during pain.

4.0 DISCUSSION AND CONCLUSION

Low back pain can trigger neuromuscular responses that are manifested in specific changes in facial expressions, such as frowning, squinting or lips[4]. These results are consistent with force inhibition and the theory that low back pain can cause visible and measurable changes in the facial expressions of those affected[7]. Objectively analyzing these changes using the software developed not only confirms the presence of pain, but also quantifies these changes in a measurable and reproducible way, offering a more accurate and reliable approach compared to subjective assessments[4, 7]. The software proved to be effective in recognizing facial changes associated with low back pain across various conditions, providing an objective analysis of these signals. The use of this technology can improve diagnosis and treatment by providing a more personalized and accurate approach, especially when verbal reporting of pain may not be reliable or possible.

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