ROLE OF ELECTROMYOGRAPHY IN THE ASSESSMENT OF LUMBAR PATHOLOGIES

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Abstract. *Lumbar pathologies can include a wide range of medical conditions such as simple myalgia or severe neurological disorders. One way to assess the behaviour of paravertebral muscles consists in using electromyography (EMG), which converts the bioelectric potential of muscle activity into numbers. These data allow us to configure an electromyographic semiology for various pathologies. The purpose of the paper is to analyse the activity of paravertebral muscles through electromyography. The results will be used to develop a rehabilitation programme aimed at reducing muscle imbalance. The study involved 10 middle-aged patients suffering from low back pain and having an average body mass index of 23.44 kg/m^2. Clinical assessment was based on the Waddell Disability Index (WDI) and the Low-Back Outcome Scale (LBOS). Muscle activity was assessed using surface EMG. Data were collected at two distinct times: while standing and during walking. Of the obtained parameters, we tracked action potential amplitude. The results allowed the classification of patients into three groups: patients with acute, subacute and chronic low back pain. Average values of the three subcategories showed important fluctuations as follows: while standing, they were 37.72 µV (acute form), 19.18 µV (subacute form) and 7.05 µV (chronic form), and during walking, they were 43.26 µV (acute form), 30.87 µV (subacute form) and 21.10 µV (chronic form). Statistical analysis was performed and significant inverse or direct correlations were observed between LBOS (-0.884) or WDI (-0.944) scales and dynamic EMG values. Thus, obvious relationships were established between surface EMG parameters and assessment scale values.*

Keywords: *electromyography, low back pain, rehabilitation.*

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Introduction

Low back pain (LBP) can be defined as a multifactorial clinical syndrome characterised by pain located between the line of the twelfth rib and the inferior gluteal folds, being often associated with leg pain (Krismer & van Tulder, 2007). Low back pain occurs in about 80% of the population, mainly at different stages during working age. Less than 1% of patients have a serious condition (bone cancer, paravertebral abscess, arthritis, trauma, or cauda equina injury), and less than 5% suffer from intervertebral disc herniation (Traeger et al., 2017). All other remaining conditions can be united under a common umbrella and are generally referred to as mechanical low back pain. Regarding the period of manifestation of symptoms, low back pain can be divided into three subcategories: acute low back pain, which

is characterised by the presence of pain for less than 6 weeks; subacute low back pain, which lasts 6-12 weeks; chronic low back pain, lasting more than 12 weeks (Hullemann et al., 2018). As one of the conditions with an increased incidence among the population worldwide, low back pain arouses the interest of specialists due to its negative implications, in the sense that it alters the patients' quality of life and is a major cause of disability.

According to Karunanayake (2014), establishing risk factors can help minimise acute low back pain and prevent it from progressing into chronic low back pain. The main risk factors for low back pain include age, sedentary lifestyle, anxiety and poor sleep quality.

Low back pain encompasses a wide range of conditions, from the simplest to the most complex ones, which is why making a correct and early diagnosis is the basic goal of patient rehabilitation. The objective examination will start from the patient's general appearance.

The posture of the patient with low back pain can have a double meaning: it is either an indication of suffering or a predisposing factor. However, posture is not a position but a complex mechanism of reflexes, behaviours and adaptive oppositional and maintenance responses that allow the body to stay upright and be functional. Posture is generated by the joint action of muscles, which will result in maintaining stability. (Levangie & Norkin, 2005)

A significant number of studies attempt to bring to the fore the correlations between spinal statics and low back pain. Smith et al. (2008) conducted a research on the sagittal spinal alignment of 766 adolescents in order to determine whether there were correlations between the photographic assessment of posture and the results of both clinical and radiological assessments and pain intensity. The study concludes that neutral sagittal thoraco-lumbo-pelvic alignment is associated with less back pain, while at the opposite pole, exacerbated alignment involves increased pain.

Nishizawa et al. (2021) investigated a group of 52 elderly patients (over 65 years of age) to determine the implications of the intervertebral disc compressive force on posture. The analysis showed that trunk flexion/extension angle and body mass were significantly associated with intervertebral disc compressive force. The parameters could be edifying for healthy adults, while for adults with spinal disorders, the obtained values were inconsistent and therefore not edifying. However, the study is relevant for the assessment of lumbar mechanical stress and posture in adults who have not been classified as pathological.

Muscle dysfunction is related to structural alterations in lumbar muscles. At a macroscopic level, muscle degeneration is characterised by a decrease in muscle mass and an increase in fat infiltration in the lumbar paravertebral muscles. Chronic low back pain is associated with atrophy in the multifidus and paraspinal muscles but not in the erector spinae. (Goubert et al., 2016)

Besides the data presented above, Goubert et al. (2017) produced a new experimental study aimed at assessing differences in muscle structure and muscle activity of the multifidus and erector spinae during trunk extension. The study involved patients with recurrent and chronic low back pain. Muscle structure characteristics and activity were assessed using magnetic resonance imaging (MRI). The results showed a higher percentage of fat infiltration in the lumbar muscles in chronic low back pain, while the percentage was smaller in the case of recurrent low back pain. At the same time, a lower metabolic activity of lumbar muscles was noted in recurrent lumbar pain, replicating a lower intensity of muscle contractions compared to chronic lumbar pain.

A review by Hestbaek et al. (2003) regarding long-term low back pain showed that 62% of patients still experienced pain 12 months after the onset of symptoms; thus, the reported prevalence was 56% for patients with a history of low back pain and 22% for those with previous painful episodes.

A topic of interest developed by Leeuw et al. (2007) demonstrates the interdependence of psychosocial factors and pain perception. The Fear-Avoidance Model (FAM) in Figure 1 suggests the influence of cognitive and emotional factors on pain experience by directing pain through coping strategies and behaviours.

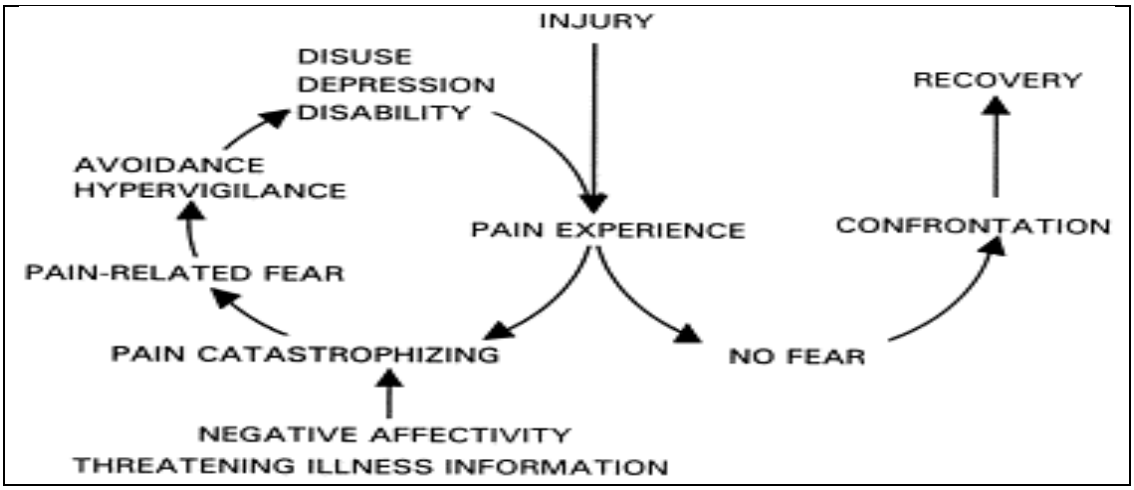

Figure 1. The Fear-Avoidance Model of musculoskeletal pain (Leeuw et al., 2007, p. 79)

We therefore observe a complex pattern of low back pain, which indicates the need for a carefully developed therapeutic approach adapted to the patient's characteristics. An assessment method dating back to 1851, which measures the electrical currents generated in muscles during their contraction, is represented by electromyography. Even though it remained within the parameters of experimental research for a long time, at the Congress of Neurology held in Paris in 1949, the scientific report delivered by Professor Fritz Buchthal led to the recognition of electromyography as a diagnosis tool.

Electromyography converts the bioelectric potentials of muscle activity into microvolts (μV). The amplitude of the current is closely related to the number of fibres contained by the examined muscle and thus becomes a reference element in the objective assessment of muscle strength (Reaz et al., 2006). A mild muscle contraction causes a simple EMG pathway consisting of monophasic or biphasic action potentials. As the contraction force increases, the EMG route improves.

McManus et al. (2020) describe in their study how surface electromyography works. The EMG signal is the electrical activity generated by a muscle contraction that can be detected by placing electrodes on the muscle area of interest. When muscles are activated, a flow of charged particles (ions) passes across the muscle fibre.

Beretta-Piccoli et al. (2019) conducted a systematic review on the reliability of surface electromyography in estimating muscle fibre conduction velocity. After analysing 17 papers, the above authors have concluded that EMG is a reliable tool for estimating conduction

velocity and can be used in clinical trials aimed at rehabilitation, provided that the electrodes are correctly positioned. Gallina et al. (2013) described how changes in surface EMG during a repetitive muscle contraction can be detected and interpreted based on the amplitude distribution. The study involved 12 male patients who performed isometric shoulder elevations up to 25% of the maximal voluntary contraction. It was concluded that the amplitude distribution measured by surface EMG was correlated with changes in the spatial distribution of motor units recruited during isometric contraction.

Disselhorst-Klug et al. (2009) consider that estimating the force generated by an activated muscle is of particular importance not only in biomechanical studies but also in clinical applications where the information about muscle forces supports the physician's decisions regarding therapeutic conduct. Surface EMG reflects the degree of skeletal muscle activation by detecting muscle force. However, there are limitations to an accurate interpretation of the relationship between surface EMG and muscle force. The main disadvantage in predicting muscle force based on surface EMG is the impossibility of measuring it directly by non-invasive methods. This leads to the need of correlating surface EMG with indirect measurements of muscle force. Through the provided parameters, electromyography proves to be a reliable assessment tool applicable to a wide range of conditions.

Research purpose. The paper aims to both analyse the activity of paravertebral muscles through electromyography and make correlations between the parameters obtained in the study and the clinical aspects of patients with low back pain. This could help analyse the muscle imbalance that occurs with low back pain.

Methodology

Participants

The research participants are 10 patients (2 men and 8 women) aged 42-61, with an average age of 49.80 years. Given that one of the predisposing factors for low back pain is weight, body mass index (BMI) was calculated for the 10 patients. Although BMI is a measurement based on height and weight, it varies depending on factors such as gender and age, if patients are under 20. As this is not the case in this study and all tested patients are over 20 years of age, the relevant values are shown in Table 1. The average BMI value for the patients included in the study is 23.44 kg/m^2. This value corresponds to a healthy BMI range.

Table 1. *Anthropometric characteristics of the patients included in the study*

Patient	Gender	Age	Height	Weight	BMI
1	F	50	1.68	60	21.26
2	F	48	1.63	65	24.46
3	F	61	1.58	55	22.03
4	F	42	1.70	63	21.8
5	F	64	1.69	70	24.34
6	M	49	1.72	75	25.35
7	F	44	1.56	57	23.42
8	F	54	1.62	68	25.91
9	M	44	1.81	82	25.03

10	F	42	1.67	58	20.8
	Minimum	42	1.56	55	20.80
	Maximum	61	1.81	82	25.91
	Mean	49.80	1.63	65.3	23.44
	Std. deviation	7.33	0.069	8.590	1.842

Inclusion criteria. All patients participating in the study suffer from low back pain in one of the three phases mentioned at the beginning of this paper, namely the acute (A), subacute (S) or chronic (C) phase. All of them identified the cause of their lumbar pain and, in most cases, associated it with maximum effort or vicious positions maintained for long periods of time. All patients are in their working age, so they follow a similar daily routine. All of them expressed their willingness to engage in a recovery programme to reduce symptoms or prevent a recurrent episode of acute LBP.

Exclusion criteria. Patients with low back pain who had previously required surgery to correct lumbar spine conditions were not considered for this study. Patient examination also involved a thorough neurological assessment. Patients with severe neurological events and those with severe associated conditions were not included in the study.

Each participant signed an informed consent, and the research was conducted in compliance with the rules of the Declaration of Helsinki, version 2013.

Measurements

In the first phase, two scales were used for patient assessment, namely the Low-Back Outcome Scale (LBOS) and the Waddell Disability Index (WDI).

LBOS is a self-report scale for patients with low back pain and consists of 13 questions related to the following parameters: current pain, employment, domestic chores, sport or active social activities, resting, treatment or consultation, analgesia, sex life, sleeping, walking, sitting, travelling and dressing. Each question is given a minimum and maximum score. The final score represents the sum of the points obtained for each item and ranges from 0 to 75; the lower the score, the higher the level of disability.

WDI is a nine-item questionnaire aimed at assessing disability in daily activities, which are often restricted by low back pain. The items refer to the following actions: heavy lifting, sitting, travelling, standing, walking, sleeping, social life, sex life and putting on shoes. Questions related to work, self-care or sports are not included in this scale. Patients only respond positively or negatively. Positive responses are given 1 point, while negative responses are given 0 points. The final score represents the sum of the points obtained for each item. The maximum score that can be obtained is 9, while the minimum score is 0; the higher the score, the higher the level of disability.

The two scales are used in clinical assessment and each one is focused on specific aspects. While the Waddell Disability Index can be addressed to a wide range of population and can be mainly used to assess daily activities, the Low-Back Outcome Scale is more extensive than the former. LBOS measures functional outcome and includes, in addition to activities of daily living, parameters such as current pain and employment. For the active population, LBOS integrates the concept of pain and how a certain level of pain (measured by the Visual Analogue Scale incorporated in the LBOS form) affects work capacity. LBOS also assesses

patients from the perspective of treatment, either they are under medication or not. As all patients included in this study are under medical treatment, a greater sensitivity to pain is provided by the Low-Back Outcome Scale, while the Waddell Disability Index is more suitable for assessing the ability to perform daily tasks.

The assessment of all research patients was completed by surface electromyography. The modular and portable Biofeedback 2000 $^{x\text{-}pert}$ system was used for electromyographic measurement. The electrodes are positioned on the surface of the skin, so the method is not invasive. The collected data are transmitted via Bluetooth to a paired computer. The software processes the information, and then translates it into charts. Biofeedback 2000 $^{x\text{-}pert}$ contains five modules. The EMG module has two channels, EMG 1 and EMG 2. Proper positioning of the electrodes is necessary for the correct collection of information. Because this study refers to lumbar pathology, the electrodes were positioned at the lumbar level on either side of the spine. While EMG 1 channel collected data from the right paravertebral muscles, EMG 2 channel provided information about the left paravertebral muscles. The neutral electrode was placed centrally on the spinous process of the L3 vertebra. The distance between electrodes in relation to the spine was about 2 cm. Before mounting the electrodes, the skin surface was cleaned to remove any dust or grease that might have altered the measurements. The attachment points of the electrodes can be seen in Figure 2.

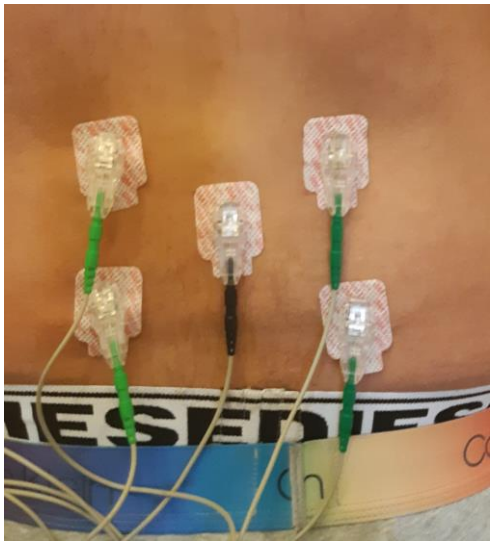

Figure 2. Electrode positioning for surface EMG measurement in LBP

Procedure

The measurements were performed at two distinct times (T1 and T2). At T1, patients were asked to maintain a fixed upright position for one minute, so monitoring was done while standing still. At T2, patients were asked to move in a straight line for one minute, so monitoring was done during walking.

Data were collected and analysed using action potential amplitude as a parameter. For the standing parameter, the results showed an average value of 21.32 µV, while for the walking parameter, the average value was 31.75 µV. These values offered the possibility of

classifying patients into three groups: patients with acute, subacute and chronic low back pain.

The results of EMG measurements were statistically processed with XLSTAT software. Correlations were obtained between all measured parameters and the scale index through nonlinear regression, which were mathematically quantifiable by exponential relationships.

Results

In order to summarise as accurately as possible the results obtained through EMG measurement and the correlations between these values and the results of the scales used in this study, Table 2 shows the numerical transposition of all information.

Table 2. *LBOS and WDI values and action potential amplitude monitored while standing and during walking*

Patient	Phase	LBOS	WDI	Static EMG Value (µV)	Dynamic EMG Value (µV)
C.V.	S	18	7	166.5	25.97
D.L.	S	21	5	21.025	28.195
I.P.	A	12	9	32.88	41.37
A.D.	S	21	7	20.075	39.135
S.T.	C	33	3	6.022	29.52
G.M.	C	41	3	8.67	18.63
M.A.	S	17	5	19.12	30.165
R.P.	C	29	3	7.29	21.18
R.F.	C	37	2	6.18	15.06
F.M.	A	6	9	42.55	45.15
	Minimum	6	2	6.022	15.060
	Maximum	41	9	166.50	45.150
	Mean	23.50	5.30	33.031	29.438
	Std. deviation	11.218	2.584	48.439	9.939

Note. S: subacute; A: acute; C: chronic.

The same values can be translated into graphs that allow comparing the parameters at the two moments mentioned above (in static and dynamic conditions) for the three groups of patients. Thus, referring to the data collected for the two EMG channels (EMG 1 and EMG 2), we can summarise the results as follows:

A) The subacute condition is specific to 4 of the 10 patients participating in the study. Figures 3, 4, 5 and 6 show the electrical activity of paravertebral muscles in the subacute phase for EMG 1 and EMG 2 channels but also for the two instances in which the measurements are performed (i.e., in static and dynamic conditions).

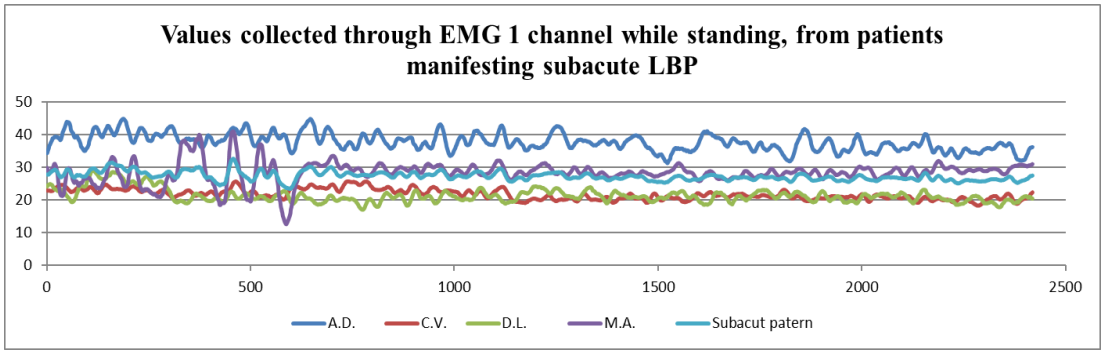

Figure 3. EMG 1 channel, static values (subacute phase)

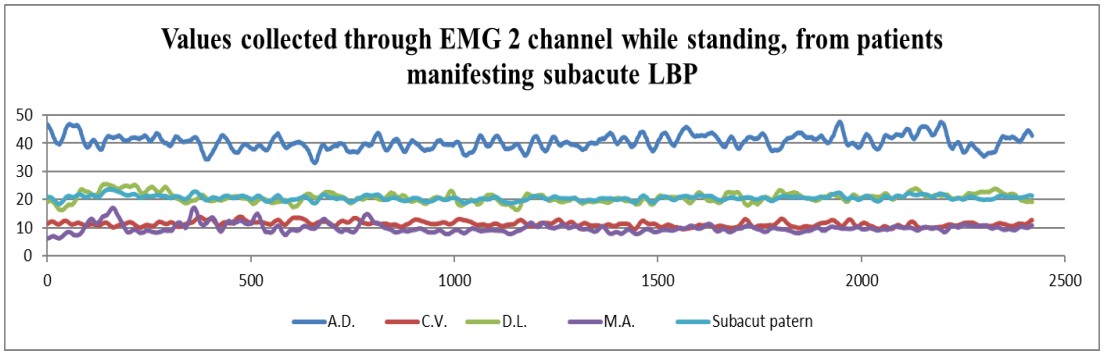

Figure 4. EMG 2 channel, static values (subacute phase)

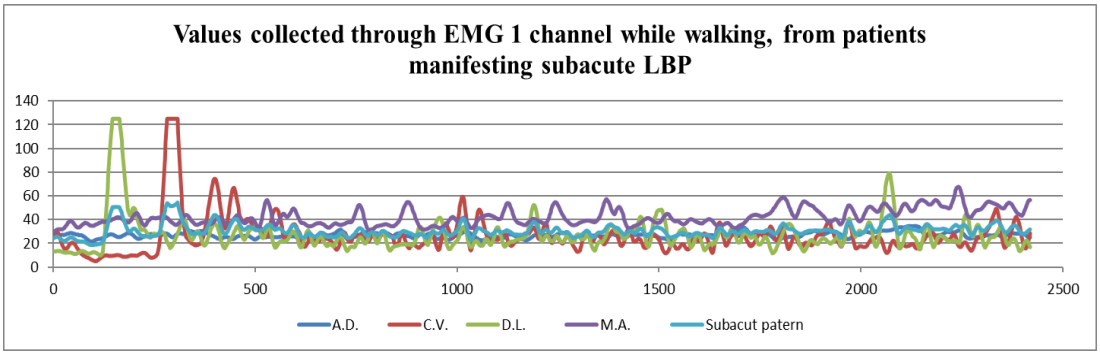

Figure 5. EMG 1 channel, dynamic values (subacute phase)

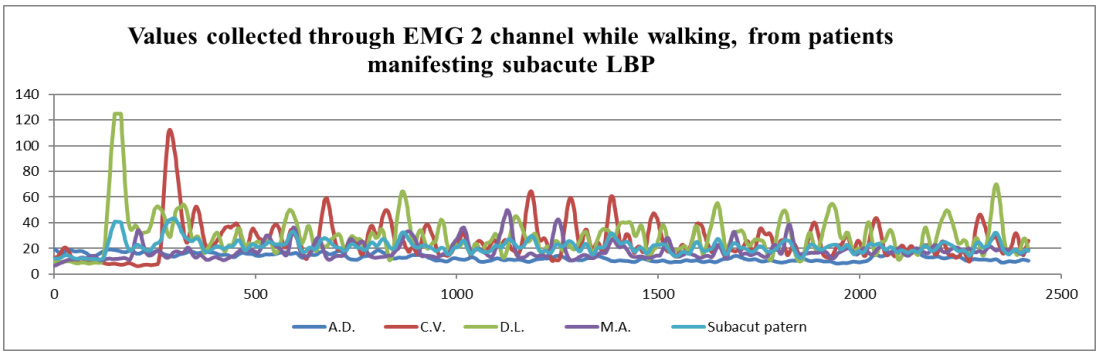

Figure 6. EMG 2 channel, dynamic values (subacute phase)

B) The chronic condition is specific to 4 of the 10 patients participating in the study. Figures 7, 8, 9 and 10 show the electrical activity of paravertebral muscles in the chronic phase for EMG 1 and EMG 2 channels but also for the two instances in which the measurements are performed (i.e., in static and dynamic conditions).

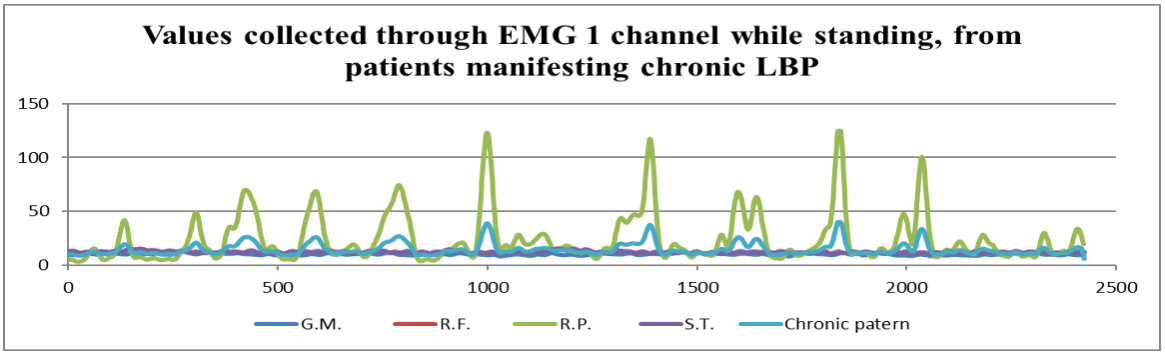

Figure 7. EMG 1 channel, static values (chronic phase)

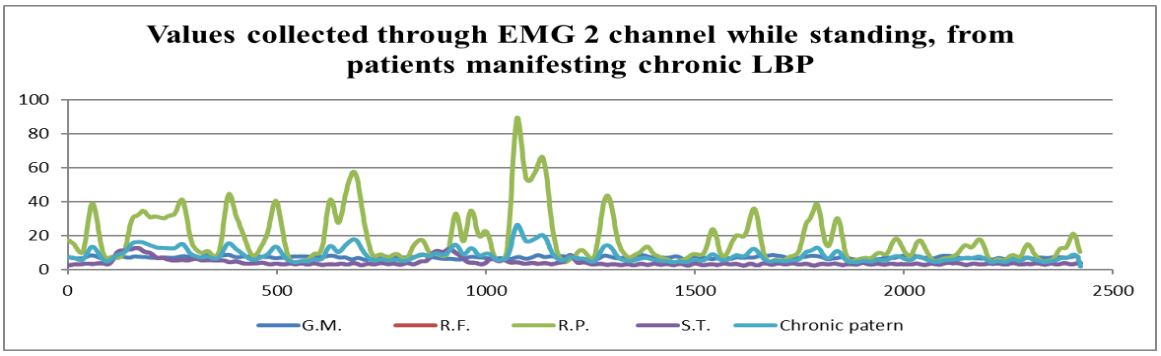

Figure 8. EMG 2 channel, static values (chronic phase)

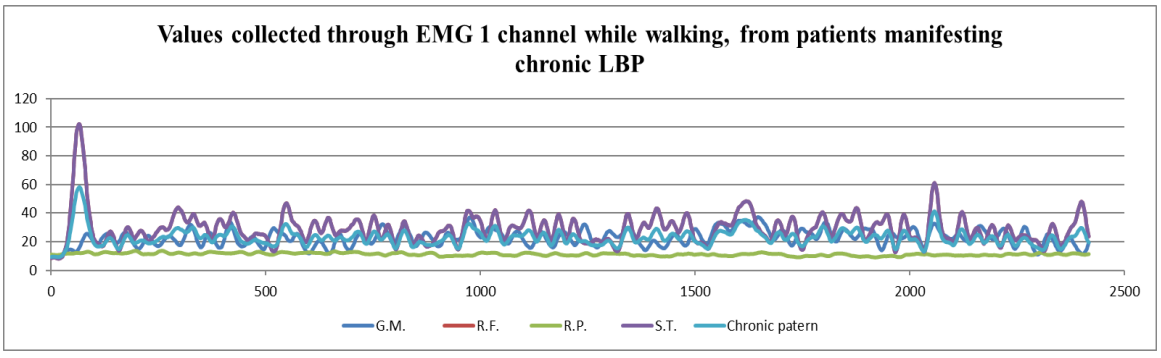

Figure 9. EMG 1 channel, dynamic values (chronic phase)

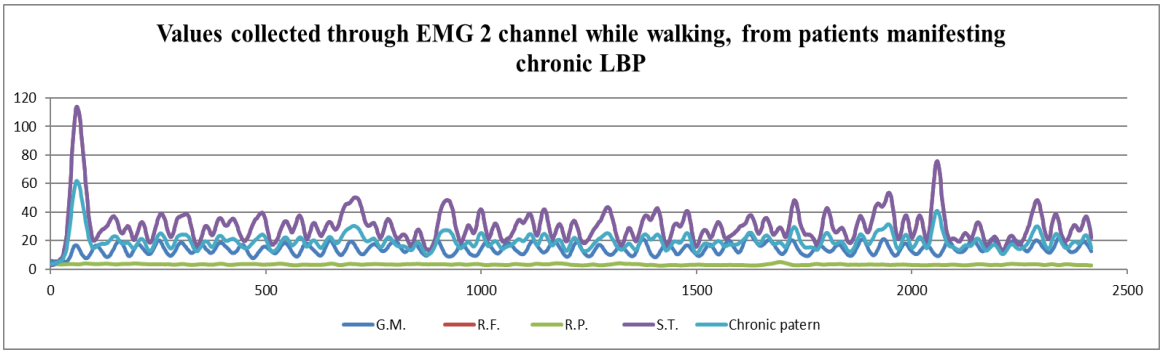

Figure 10. EMG 2 channel, dynamic values (chronic phase)

C) The acute condition is specific to 2 of the 10 patients participating in the study. Figures 11, 12, 13 and 14 show the electrical activity of paravertebral muscles in the chronic phase for EMG 1 and EMG 2 channels but also for the two instances in which the measurements are performed (i.e., in static and dynamic conditions).

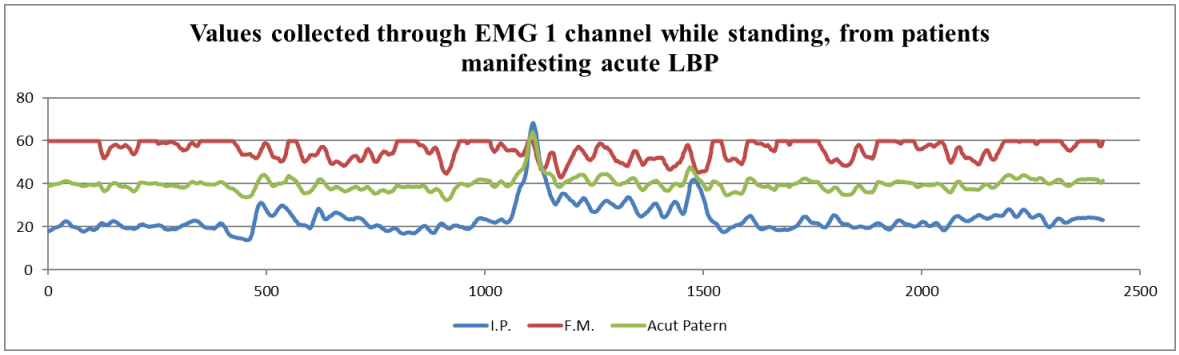

Figure 11. EMG 1 channel, static values (acute phase)

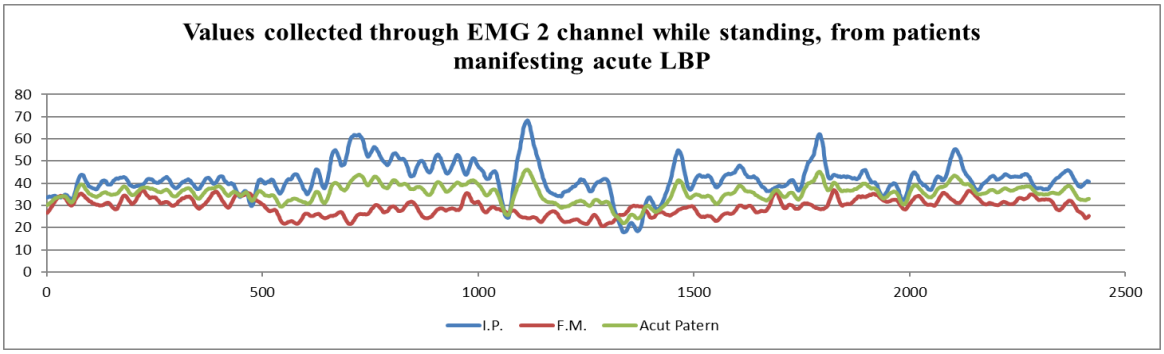

Figure 12. EMG 2 channel, static values (acute phase)

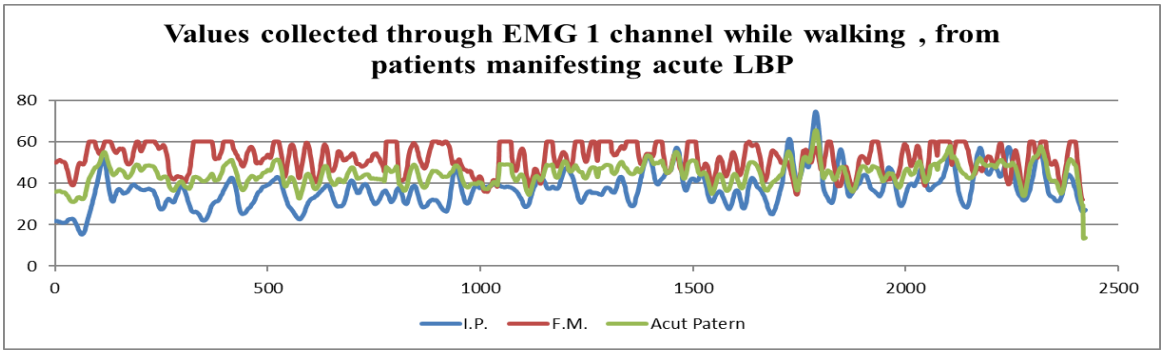

Figure 13. EMG 1 channel, dynamic values (acute phase)

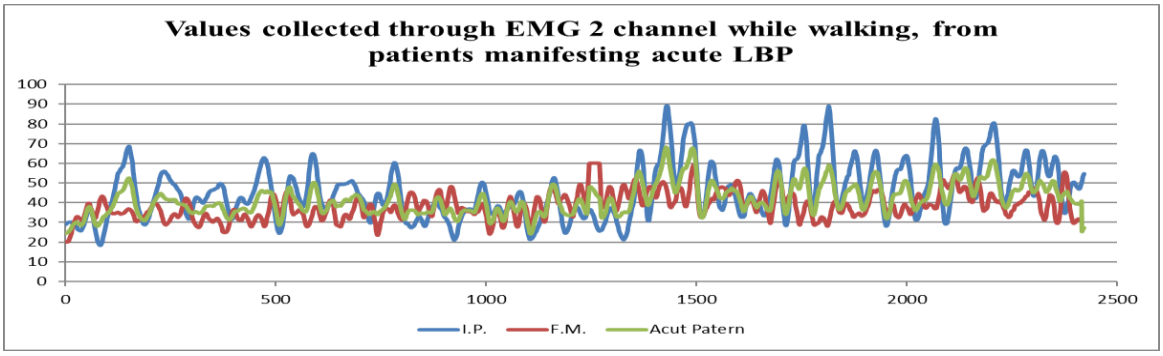

Figure 14. EMG 2 channel, dynamic values (acute phase)

Analysing and comparing the values provided by the EMG recordings for all three phases (subacute, acute, chronic), it can be seen that the acute phase indicates large muscle imbalance and high amplitude of the EMG signal. This would mean that different motor units are recruited to reduce pain by adopting antalgic positions.

XLSTAT software transposed the correlations between EMG values and scale values. Pearson's correlation coefficient matrix is shown in Table 3.

Table 3. *Correlations between EMG values and anthropometric values and the two scales (LBOS and WDI)*

Variables	Weight	BMI	LBOS	WDI	Static EMG Value (µV)	Dynamic EMG Value (µV)
Weight	**1.00**	0.74	0.91	-0.85	-0.40	-0.80
BMI		**1.00**	0.82	-0.91	-0.60	-0.80
LBOS			**1.00**	-0.91	-0.40	-0.884
WDI				**1.00**	0.46	0.944
Static EMG Value (µV)					**1.00**	0.10
Dynamic EMG Value (µV)						**1.00**

Correlations are established between LBOS and WDI scale scores and dynamic EMG values but also between scale scores and BMI. This means that the assessment of pain and functionality using the above-mentioned scales and patient classification into one of the three phases (subacute, acute, chronic) could be correlated with electrical muscle activity, thus allowing to assess muscle imbalance in different clinical situations.

Due to the strong correlation and the use of nonlinear mathematical regression, the following dependence equations between scales and EMG measurements are established:

- For the WDI scale - model equation:

Dynamic EMG Value (µV) = 15.9903*exp(0.113978*WDI).

This is graphically represented in Figure 15.

- For the LBOS scale - model equation:

Dynamic EMG Value (µV) = 54.0066*exp(-0.0263495*LBOS).

This is graphically represented in Figure 16.

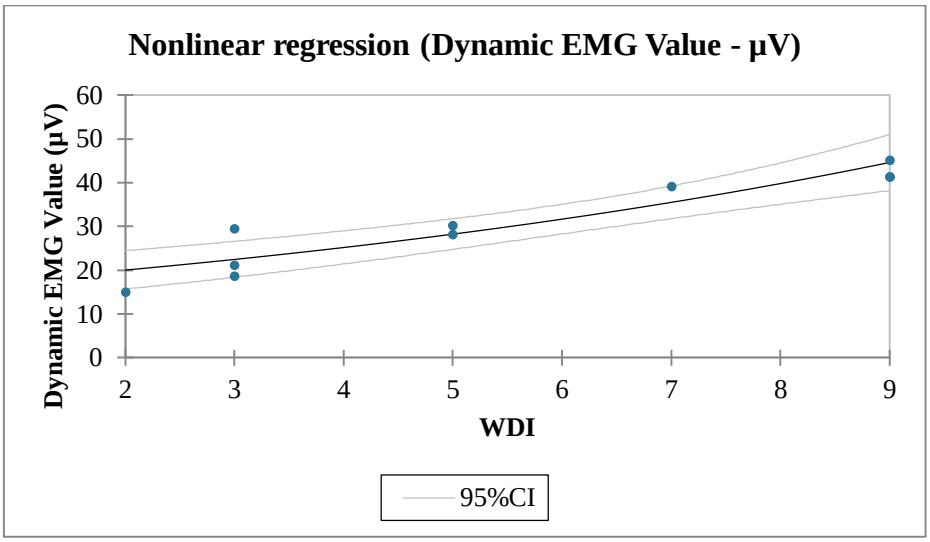

Figure 15. Graphical representation of the regression equation for WDI (Dynamic EMG)

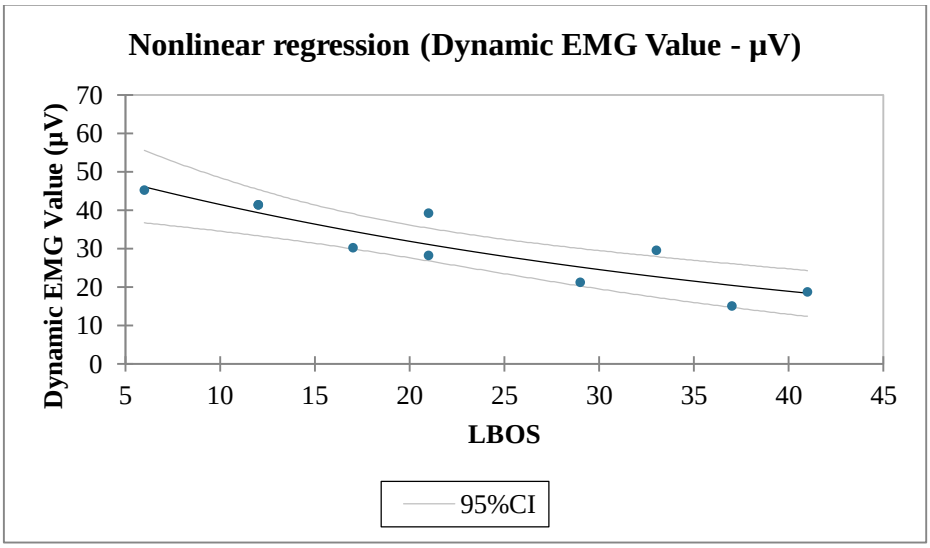

Figure 16. Graphical representation of the regression equation for LBOS (Dynamic EMG)

Discussion and Conclusion

There are clear indications of the relationship between low back pain and damage to the paravertebral muscles. Several studies conducted in this regard demonstrate the risk of increased low back pain when electrical muscle activity is inappropriate (Mohseni-Bandpei et al., 2014).

As mentioned before, the values collected in the present study (which were measured in µV) allowed the classification of patients into three groups: patients with acute, subacute and chronic low back pain. Average values of the three subcategories showed important fluctuations as follows: while standing, they were 37.72 µV (acute form), 19.18 µV (subacute form) and 7.05 µV (chronic form), and during walking, they were 43.26 µV (acute form), 30.87 µV (subacute form) and 21.10 µV (chronic form). The results also emphasised correlations between action potential amplitude values and assessment scale scores. It was thus observed that, for major disabilities, the values collected by surface EMG corresponded to acute or subacute forms of low back pain.

A careful analysis of the back muscles (in this case, the lumbar ones) highlighted that electrical muscle activity led to the clinical staging of the patient. In recent years, the interest in developing a non-invasive assessment method for muscle impairment has constantly grown. As an assessment method, electromyography provides details about muscle integrity through specific parameters. Therefore, several research studies support the significant contribution of a clear and accurate patient assessment. The result of this step will be seen subsequently in the recovery process.

The literature review conducted by Mohseni-Bandpei et al. (2000) reveals that the assessment of paravertebral muscles using surface EMG is proven to be a reliable and valid tool for differentiating patients with low back pain from normal individuals. According to the same study and based on the documentation of articles published over a period of 15 years, surface EMG also allows the assessment/re-assessment of therapeutic techniques applied to patients with low back pain. The EMG technique is useful in the initial stages of low back pain and during the rehabilitation programme.

Kramer et al. (2005) examined 31 patients with chronic low back pain versus healthy individuals. The paravertebral muscles of patients included in the study were assessed by surface electromyography. The EMG examination tracked the value of maximal voluntary contraction, which was measured during an endurance test that required the patient to push against the free lever arm but not actually moving it; if pain occurred or the position could not be maintained within five-degree deviation, the test was aborted. The authors concluded that the back muscles of patients with chronic low back pain appeared to be less fatigable than those of individuals in the control group.

Heydari et al. (2010) conducted a 2-year prospective study to investigate the association of low back pain with EMG variables over time. Thus, 120 patients were assessed by surface EMG in order to establish the degree of disability caused by low back pain. The recordings were performed for isometric contractions and acquired from erector spinae muscles at the level of L4/L5. At the end of the follow-up period, there were changes in EMG parameters, which were directly associated with the clinical status of patients.

Hubley-Kozey and Vezina (2002) show in their study the differences between the EMG recordings of healthy participants versus patients with chronic low back pain after examining their abdominal and lumbar muscles. The authors concluded that the group of patients with low back pain used different activation patterns indicating a lack of synergistic coactivation for the investigated muscle areas. The obtained results provide a basis for classifying the impairment associated with low back pain and could be a starting point for assessing the effectiveness of therapeutic interventions to improve muscle coactivation.

Mayer et al. (2009) developed a rehabilitation programme for patients suffering from low back pain. Action potential amplitude, a parameter detected by surface electromyography, was used as a guideline. The participants were both healthy individuals and patients with low back pain. The rehabilitation programme consisted of trunk mobilisation (flexion-relaxation) exercises. The results obtained through EMG measurements showed a slight change in lumbar range of motion during rehabilitation, but no significant change was noted in the patients' overall status, which was revealed by the collected EMG parameters.

A brief review of the studies on the relevance of EMG use in lumbar disease is provided in Table 4. Referring to specialised articles and the results obtained in the present paper, we can observe the correlations between the degree of muscle damage and the parameters collected by using surface EMG. It can therefore be concluded that the EMG technique is a tool for assessing and monitoring lumbar conditions. The purpose of the assessment is to identify the muscular status in order to later design an individualised rehabilitation programme adapted to the patient's needs, depending on the severity of the injury.

Table 4. *Some relevant studies in the assessment of lumbar pathologies by surface EMG (sEMG)*

Author and year of the study	Study participants	Study period	Study organisation	Therapeutic approach	Assessment method	Association of sEMG parameters with the clinical status
Mohseni-Bandpei et al. (2000)	-	15 years follow-up	Literature review	Kinetic rehabilitation + Medication	sEMG	YES
Kramer et al. (2005)	31 patients		Study	Kinetic therapy	sEMG	YES
Heydari et al. (2010)	120 patients	2 years	Study		sEMG	YES
Hubley-Kozey & Vezina (2002)	38 patients	1-year	Study	Kinetic therapy	sEMG	YES
Mayer et al. (2009)	134 patients	13 months	Study	Kinetic therapy	sEMG	YES

The present study and the literature review have led us to the following conclusions:

1. Low back pain can take many forms and can include a wide range of conditions.

2. Early diagnosis of low back pain and its correct classification based on reported signs and symptoms contribute to the proper management of the condition.

3. Assessing patients with low back pain involves the completion of a well-established circuit that starts with their medical history and physical examination and continues with a number of tests specific to each condition.

4. In clinical terms, the present study allows the classification of patients into three groups: patients with acute, subacute and chronic low back pain.

5. The assessment of patients with low back pain is completed by minimally invasive paraclinical examinations (radiography, MRI, EMG) that can confirm and support the clinical diagnosis.

6. Surface EMG measures the electrical activity of lumbar muscles and detects the muscle contraction level.

7. Surface EMG and statistical data processing highlight obvious correlations between the action potential amplitude as an EMG parameter and the clinical aspect of patients with low back pain, which has actually been the main purpose of this paper.

8. Since damage to the paravertebral muscles proves to be specific to the type of condition, the therapeutic programme needs to be individualised.

9. The conclusion is that, for each phase of pain (acute, subacute or chronic), the type and time of rehabilitation are adapted to the levels of pain and muscle damage through medication and physical therapy. This is specific to each patient.

The development of a therapeutic plan in accordance with the EMG measurement represents a future direction of the present study, which could result in accelerating the recovery process of patients with low back pain.

Adequate pain management and condition control are aimed at minimising symptoms and degeneration. All the above improve the patients' quality of life in physical, mental and emotional terms.

As far as we know, the current study is the first to test the interrelation between LBOS and WDI scales and EMG values collected from patients with low back pain. As previously mentioned, there are strong negative correlations between dynamic EMG and weight (-0.80), BMI (-0.80) and LBOS (-0.884), and direct positive correlations between dynamic EMG and WDI (0.944). LBOS and WDI scales suggest a significant inverse correlation (-0.91).

The original contribution of the study consists in addressing two different directions: on the one hand, the correlation established between the data collected for the assessment of pain and function in patients with acute, subacute and chronic low back pain, and on the other hand, the muscle contraction behaviour recorded by surface EMG. Such an approach can contribute to the functional diagnosis of low back pain.

This study is limited by the accuracy of patient responses. The effect of possible desirable responses is known in the literature when explicit instruments (questionnaires) are applied (Predoiu et al., 2022). EMG data collection can also represent a limitation related to electrode positioning and the quality of the electrical signal.

Although the effectiveness of EMG has been clearly identified, its interdependence with both scales can be considered restrictive because the number of participants in the present study is relatively low. Expanding the study and including a larger number of patients would allow validation of the existing results.

Static EMG measurements show no correlation with any existing parameters. This may open up multiple options for further research.

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