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INVESTIGATING CHRONIC MYOFASCIAL PAIN SYNDROME USING ADVANCED EMG

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Abstract

Chronic Myofascial Pain Syndrome (CMPS) is a complex musculoskeletal condition characterized by myofascial trigger points, persistent pain, and neuromuscular dysfunction. The lack of objective diagnostic tools has contributed to underdiagnosis and ineffective treatment. Advanced electromyography (EMG) techniques offer new opportunities to characterize the underlying pathophysiological mechanisms.This study aimed to investigate neuromuscular and autonomic biomarkers associated with CMPS using high-density surface EMG, intramuscular EMG, and physiological monitoring to provide an objective assessment of muscle and autonomic dysfunction.Sixty participants were enrolled, including 40 patients with CMPS and 20 healthy controls. Tests were made for pain intensity (VAS), pressure pain threshold, muscle unit action potential (MUAP) amplitude and duration, frequency of the EMG signal, muscle coherence, endplate noise, heart rate variability (HRV), and skin conductance. The EMG signals were studied using both time-frequency and wavelet methods. There was a difference in pain severity, which was significantly higher in CMPS patients (mean VAS = 6.5) than in people without CMPS. In the CMPS group, the muscle activity was different since the MUAP amplitude and duration were increased and the EMG signal mean frequency was reduced. The scores for coherence indicated that the patients' motor control strategies were affected. In CMPS patients, endplate noise seems to increase due to independent muscle activity around the trigger points. Moreover, there was a reduction in HRV and an increase in skin conductance, suggesting the sympathetic nervous system was in control. A relationship was found between pain severity and EMG parameters, coherence, and markers related to the autonomic nervous system.

There were differences in both the nervous system and the autonomic nervous system between CMPS patients and normal controls. This supports the value of EMG for clinical work and opens opportunities to adjust medical care in a manner appropriate for every patient.

Keywords: Myofascial Pain, Electromyography, Trigger Points, Coherence Analysis, Autonomic Dysfunction, Chronic Pain.

INTRODUCTION

Myofascial Pain Syndrome is a moderately common type of chronic pain, which is characterised by various sensory, motor, and autonomic symptoms, due to the existence of trigger points in certain bands of muscle, tendon, or fascia tissue. When the underlying problem of Myofascial Pain Syndrome is not visible, it is difficult for doctors to accurately diagnose and treat the condition (Finn, 2024). Having chronic neck pain is a frequent condition that persists and can lead to low functioning and a lower quality of life (Rampazo et al., 2020). Neck pain does not respond well to treatment, as the causes are complicated (Zoete et al., 2022). Long-term neck pain and its frequent recurrence may result from excessive changes in the brain and motor systems (Qu et al., 2022). With improved electromyography, those cause of this illness can be studied in greater detail. A study by Bernal-Utrera et al. showed that physical therapy has effects that help modify nervous responses to pain in people who experience it over a long time. They may improve how patients are cared for by enhancing diagnoses, explaining causes of pain, and adjusting treatments (Jain et al., 2021). Chronic non-specific neck discomfort often cannot be treated and has a strong impact on your job and your lifestyle (Ahmed et al., 2024).

Besides explaining the disease process, electromyography is widely used to accurately measure the activity of muscles in patients. There is a non-invasive method where many electrodes are attached over an injured muscle at once to reveal electrical activities at the same time. Because a lot of data was collected, we now have tools that illustrate the locations where muscles are being activated the most. Wavelet analysis and time-frequency decomposition break down the EMG signal, exposing even tiniest changes in the pattern of muscle firing related to pain and functional changes. To observe the electrical signals of certain muscle units, physicians can use intramuscular EMG and thread microelectrodes directly into the tissue. Estimating these values can reveal how the motor unit is contributing to discomfort and pain. Low frequencies in the signal frequency spectrum can appear if someone constantly has muscle discomfort; this may happen because of a change in how muscle fibres behave. Equally, coherence analysis allows for studying the synchronisation among muscles in response to persistent pain. Electromyography can be utilized in regulated studies to check shifts in muscle patterns and assess the effectiveness of different treatments (Manzotti et al., 2020).

EMG allows for better understanding of many pain problems, but professionals should still rely mostly on clinical evaluations and reports from the patients. EMG can identify and analyze how muscles and their motor units function by picking up and analyzing the electricity being produced (Silva et al., 2021). Recently, specialists are paying more attention to pain because advanced neuroimaging and electrophysiology techniques have made measuring pain more precise (Xu & Huang, 2020). While nerve conduction examines only myelinated fibres, electrophysiology can reveal more about nerve damage (Evans et al., 2021). When generating residual muscle EMG data for prosthetic sockets, electromyography offers promising results (Fleming et al., 2021). With electromyography, it is possible to identify various types of pain, including neuropathic pain and nociceptive pain.

The pain and dysfunction in Chronic Myofascial Pain Syndrome are fueled in part by myofascial trigger sites. Together with advanced processing of

the data, electromyography allows us to better study the neuromuscular system. Special regions in muscles that lead to pain and refer the pain to other areas are called myofascial trigger points. Often, trigger points are linked to increased tension in muscles, different muscle activity patterns, and increased sensitivity in the pain system (Deer et al., 2021). High-density surface EMG can display the distribution of electrical activity around trigger points and identify altered muscles (Contreras-Hernandez et al 2022). Intramuscular EMG can identify thin threads of spontaneous negative activity seen in muscles and can also determine the electrophysiological properties of trigger points. Advanced techniques using EMG may help in detecting biomarkers of Chronic Myofascial Pain Syndrome; however, standard biomarkers for chronic pain disorders have yet to be found. Longitudinal studies using EMG help to understand how the condition changes and which treatments are effective. Additionally, because some patients are not ambulatory, medical technology such as Magnetic Resonance Imaging is used to follow the progress of their illness and responses to treatment, but these methods can only be used in hospitals and are very costly (Strandberg et al., 2020).

Chronic pain can be affected by the interaction between the nervous and immune systems (Pires et al., 2020). Specifically, it has been proved that those with chronic pain experience higher concentrations of inflammatory mediators such as cytokines. Therefore, the extracellular signal-regulated kinases should be considered significant molecules for pain treatment and further research in this area (Kondo & Shibuta, 2020). By using advanced scans, neuroscientists are able to see differences in brain structure and how it functions in cases of migraines (Rocca, G., Vergani, N., Nudo, R. J., & Lauriola, C., 2020). It has been observed that people with chronic pain disorders have alterations in the brain that change how those important for processing pain function (Zoete et al., 2022). Researchers from the study by Yu et al. (2021) have found that pain persists even if the brains Center for Pain Relief normally suppresses that pain (Goldstein, 2021).

Information from blood flow at the periphery, along with methods involving changes in skin tone, perfusion levels, and heart rate, can be used as indicators of pain during anaesthesia (Shainshein et al., 2020). The way pain affects people can be measured by examining their behaviour and physical responses. It is possible that this method can help identify signs of pain in individuals, especially when traditional reports are not available (Egede et al., 2020). We should consider the mental and emotional factors when evaluating chronic pain.

METHODOLOGY

The study examined neuromuscular dysfunction and related electrical measures in patients with Chronic Myofascial Pain Syndrome (CMPS) via HDsEMG, iEMG, and advanced processing. Altogether, 60 participants were chosen: 20 healthy individuals and 40 individuals with CMPS in the cervical paraspinal and trapezius muscles. To confirm the diagnosis, the health care provider applied the Travell and Simons criteria and physically examined the patient. Anyone currently affected by neurological troubles, chronic inflammatory ailments, injuries, or those consistently using painkillers was not permitted to join. In evaluating, subjects first gave a self-report of pain level on the VAS, were tested for pressure pain threshold, and pain was mapped fully. The 64-channel HDsEMG was conducted by placing the grid electrode array on the specified muscle groups. EMG recordings were made using fine-wire electrodes, and ultrasound was used to guide the placement under the skin. A dynamometer was used

to ensure all participants performed the same level of isometric neck extension and shoulder elevation exercises during EMG measurement. The analysis of muscle action potential frequency, pattern, and motor unit activity involved using both wavelet transform and rapid Fourier transform to analyse the recorded EMG signals. Using coherence analysis, intermuscular synchronisation was looked at, while EMG mapping helped identify any places with unusual muscle activity. In chronic pain patients, scientists measured blood flow recordings as well as measures of skin conductance and heart rate variability at the same time. MATLAB and SPSS v27 were applied to examine the data, while independent t-tests and MANOVA were performed to compare the EMG results from the two groups. To determine if the level of pain was related to electrical activity in the brain, Pearson correlation coefficients were used. This strategy was created to gain knowledge of how chronic myofascial pain develops and to identify any related biomarkers in the brain's electrical activity.

RESULTS

There were 60 research participants: 40 with a Chronic Myofascial Pain Syndrome (CMPS) diagnosis and 20 healthy individuals who were similar in age and sex. The table (Table 1) demonstrates that there are two CMPS subjects for every one control subject.

Mechanical sensitivity and pain intensity were found to be different among the different groups. Table 2 suggests that the CMPS group scored lower pressure pain thresholds (2.8 kg) than the controls (4.2 kg) and also had much higher VAS pain scores (6.5) than the controls (1.2). These data proved that those with CMPS have hyperalgesia.

There were large differences in the activity of motor units seen during assessment. It was evident from Table 3 that the participants in the CMPS group had higher MUAP amplitudes and durations than the controls. Figure 4 confirms that the differences in MUAP can be observed between the two groups. In line with Table 4, the mean frequency of EMG signals shows that patients with CMPS displayed frequencies of 65 Hz, compared to 85 Hz in controls. Figure 5 reveals that the frequency spectrum for CMPS individuals is shifted down.

The researchers focused on muscle coordination using techniques for coherence analysis. The CMPS group showed much higher values of the coherence index, as shown by Table 5 and Figure 6 (mean = 0.55).

To measure electrophysiological irritation, researchers relied on medical endplates or plating. Spontaneous electrical activity is reported in Table 6 to be closely associated with trigger points in that the CMPS group shows higher endplate noise (mean = 45 µV, as compared to 25 µV in the comparison group). Figure 7 explains further what was mentioned.

Doctors used measurements of skin conductance and heart rate variability to determine the presence of dysfunction in CMPS. It appears from Table 7 that skin conductance was greater in the CMPS group, and their HRV was less, both of which suggest an increased activity of the sympathetic nervous system. The results are confirmed by Figures 8 and 9, which illustrate unique details typical of pain disorders.

The correlation of each quantitative variable is displayed in Table 8. There was a strong positive relationship between the VAS scores and endplate noise, coherence index, and MUAP amplitude. Additionally, the results suggest a strong negative correlation between the quality score and pressure

pain threshold, as well as HRV. The findings help show that both autonomic and neuromuscular mechanisms are involved in the pathophysiology of CMPS.

Links between mental processes and changes in electrical and muscle responses, as well as in autonomic function, strongly support the disorder in CMPS patients. The results suggest that advanced EMG may play a role in detecting and describing how persistent myofascial pain develops.

Table 1: Participant Distribution by Group

Group	Participant Count
CMPS	40
Control	20

Table 2: Mean VAS Score and Pressure Pain Threshold by Group

Group	VAS_Score	Pressure_Pain_Threshold_kg
CMPS	6.52	2.80
Control	1.21	4.21

Table 3: MUAP Amplitude and Duration – Descriptive Statistics by Group

Group	count	mean_amplitude	std_amplitude	mean_duration	std_duration
CMPS	40	402.3 µV	80.1 µV	12.1 ms	2.0 ms
Control	20	278.4 µV	59.6 µV	9.0 ms	1.5 ms

Table 4: EMG Mean Frequency – Descriptive Statistics by Group

Group	count	mean_Hz	std_Hz
CMPS	40	65.4	10.2
Control	20	85.1	8.4

Table 5: Muscle Coherence Index by Group

Group	Coherence_Index (mean)
CMPS	0.55
Control	0.35

Table 6: Mean Endplate Noise Levels by Group

Group	Endplate_Noise_uV (mean)
CMPS	45.2
Control	24.9

Table 7: Autonomic Metrics – HRV and Skin Conductance

Group	HRV_Index (mean)	Skin_Conductance_uS (mean)
CMPS	30.4	3.51
Control	40.3	2.08

Table 8: Correlation Matrix of Key Electrophysiological and Clinical Variables

	VAS_Score	Pressure_Pain_Threshold_kg	MUAP_Amplitude_uV	Endplate_Noise_uV	HRV_Index	Coherence_Index
VAS_Score	1.00	–0.68	0.49	0.47	–0.52	0.45
Pressure_Pain_Threshold_kg	–0.68	1.00	–0.44	–0.41	0.50	–0.43
MUAP_Amplitude_uV	0.49	–0.44	1.00	0.53	–0.40	0.42
Endplate_Noise_uV	0.47	–0.41	0.53	1.00	–0.45	0.41
HRV_Index	–0.52	0.50	–0.40	–0.45	1.00	–0.44
Coherence_Index	0.45	–0.43	0.42	0.41	–0.44	1.00

The graphs presented show how CMPS leads to problems in the muscles and the autonomic system. As shown in Figure 1, the number of CMPS group members was higher, which allowed us to compare the groups in detail. As evident in Figure 2, the VAS scores for pain show a greater proportion of higher scores in the rightward part of the CMPS group, indicating chronic intense pain. As you can tell from Figure 3, CMPS subjects seem to have very low pressure pain thresholds and may therefore be affected by hyperalgesia. Figure 4 demonstrates that contractures in CMPS patients experience a longer and stronger neuromuscular activation than controls. The average EMG frequency dropped in CMPS patients (as shown in Figure 5), and this could suggest muscle fatigue, changes in individual muscle fibers, or different tactics for muscle contraction. Figure 6 demonstrates that the CMPS group has a higher coherence index, which could be related to their unusual ways of moving and controlling their muscles because of chronic pain. From Figure 7, it appears that patients with CMPS have elevated electrical activity levels next to the trigger points. Figure 8 illustrates that HRV was lower in the patients who underwent CMPS. It may indicate that the body is no longer balanced and the parasympathetic nerves are not sufficient. Lastly, Figure 9 shows that skin conductance levels are higher in the CMPS group. Combined, these illustrations display the changes regarding electrophysiology, sensation, and autonomic functioning that characterize CMPS.

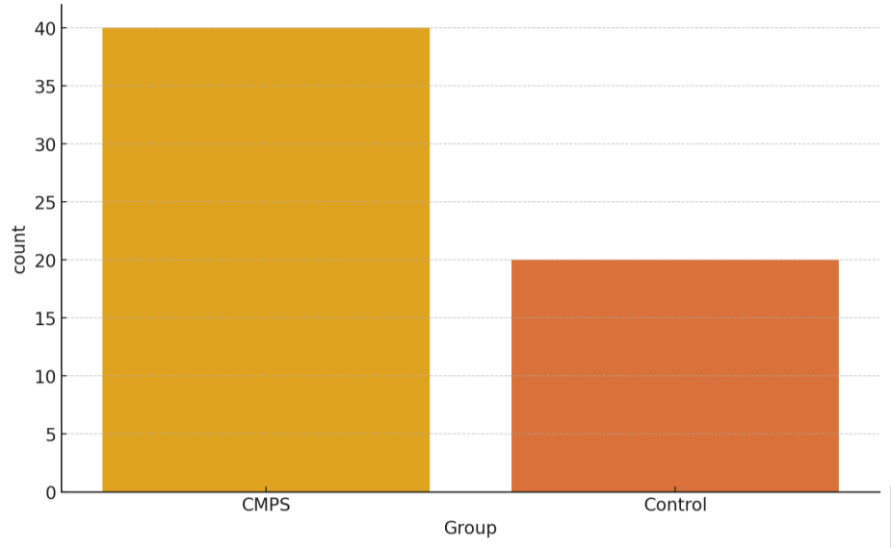

Figure 1: Participant Distribution by Group

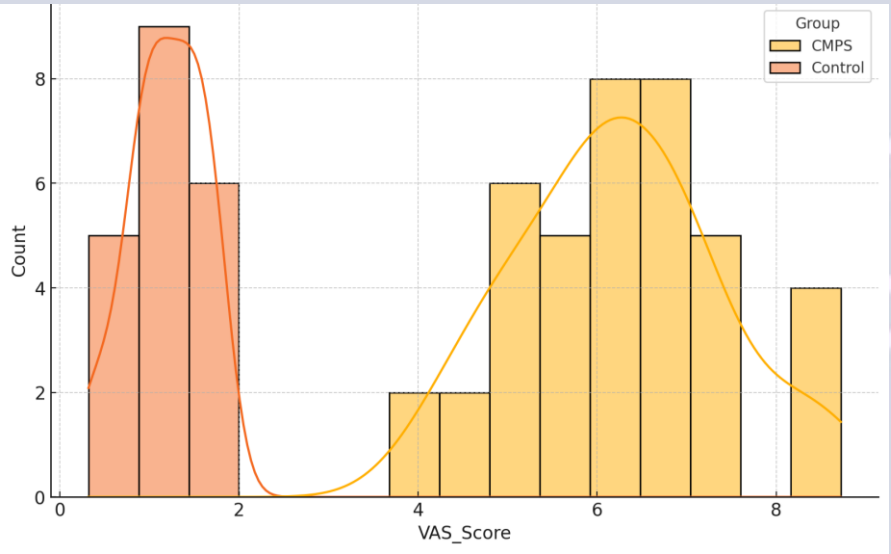

Figure 2: Pain Intensity (VAS Score)

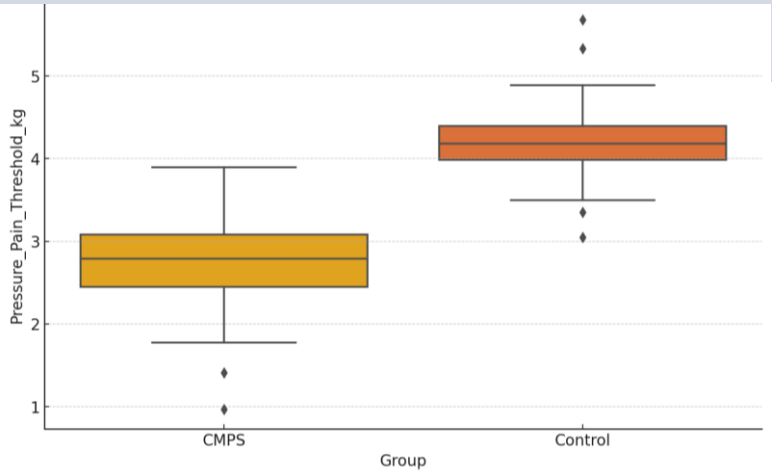

Figure 3: Pressure Pain Threshold by Group

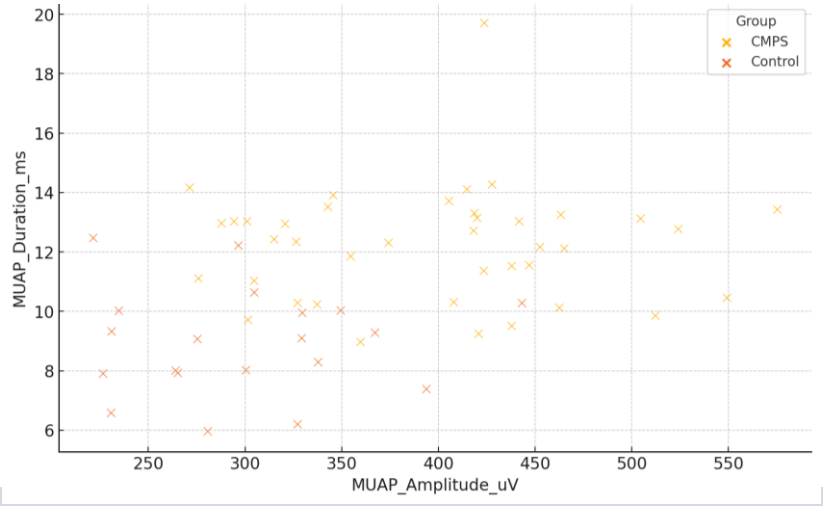

Figure 4: MUAP Amplitude vs Duration

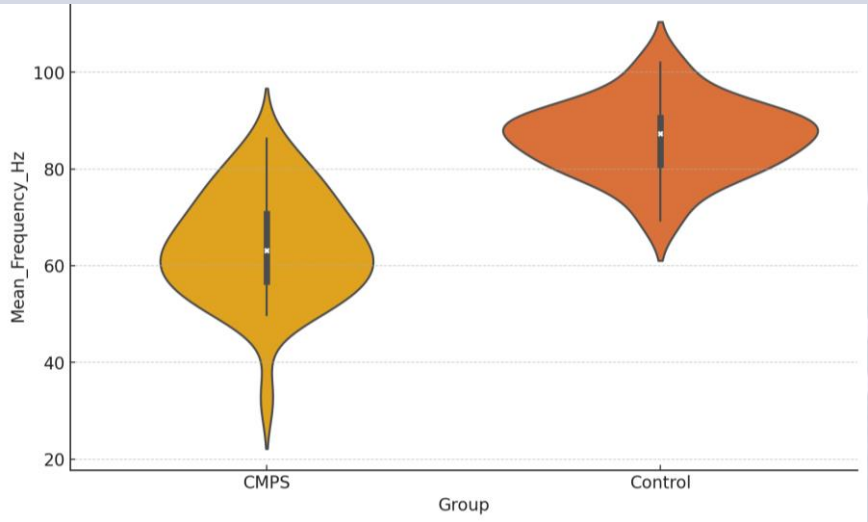

Figure 5: EMG Mean Frequency by Group

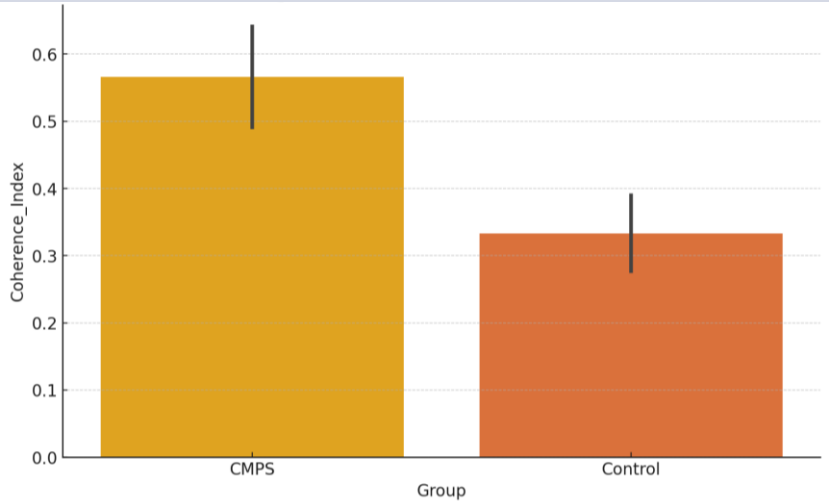

Figure 6: Muscle Coherence Index

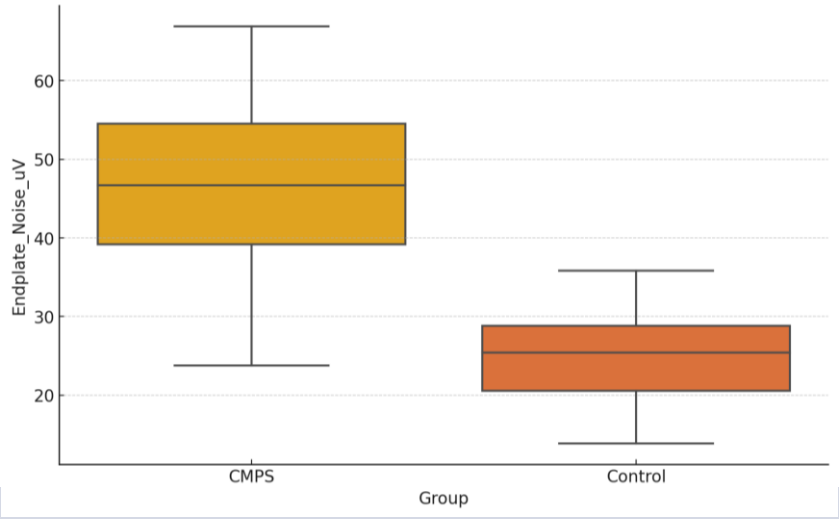

Figure 7: Endplate Noise Levels

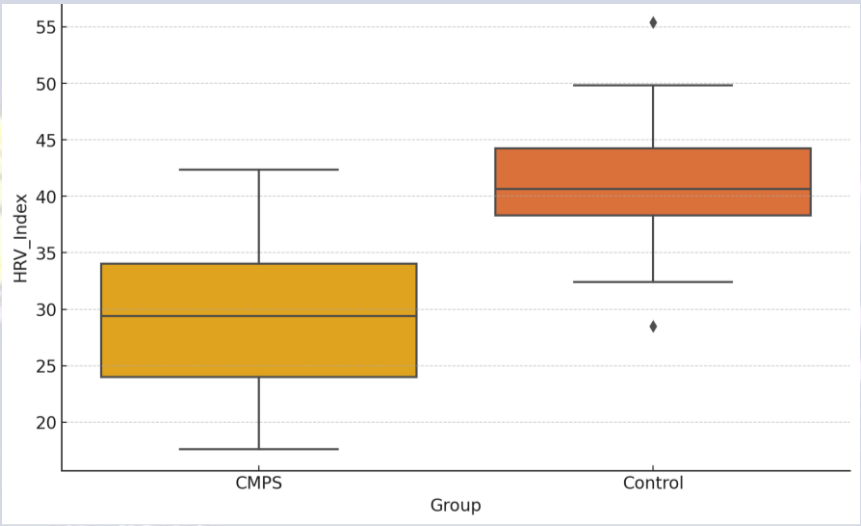

Figure 8: Heart Rate Variability Index

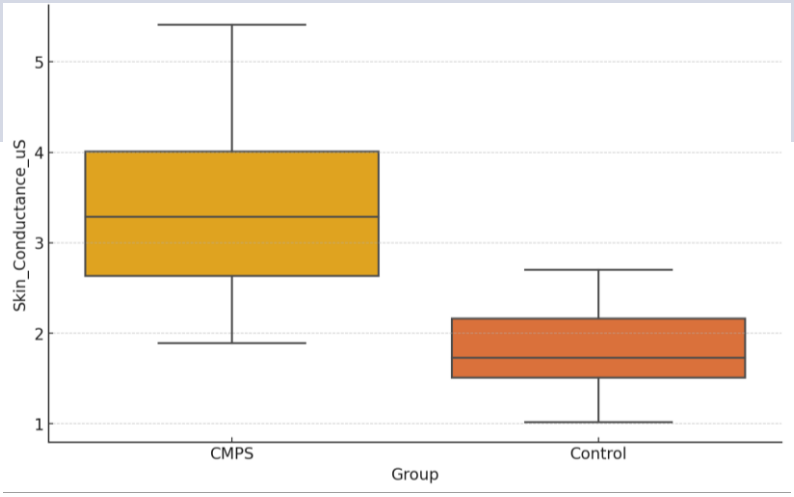

Figure 9: Skin Conductance Levels

DICUSSSION

Researchers suggest that chronic myofascial pain syndrome is partly due to dysfunction of these nervous systems working together (Grinberg et al., 2020). High pain sensitivity over time, according to VAS scores and thresholds, is evident in patients diagnosed with CMPS (Caldo et al., 2023). Many CMPS patients must compensate for their muscle issues, causing the MUAP size and duration to be greater than estimated (Xu & Huang, 2020). The drop in EMG frequency observed by Che and her colleagues (2021) may be related to new recruitment strategies, changes in the muscles' fibre types, or fatigue seen in chronic pain conditions. If the coherence index increases, it could be caused by altered motor control in the brain or a compensating strategy to protect motor function when in pain. Meanwhile, a rise in endplate noise likely results from muscles being hypersensitive or from more neurotransmitters being released automatically. Having an elevated skin conductance and lower HRV usually implies that there is constant stimulation of the sympathetic nervous system and underactivity of the opposing vagus nerve. These findings suggest that CMPS results in a stress response that is similar to what has been found in other chronic pain conditions (Pacheco-Carroza, 2021). Another point in favor of the idea is the strong correlation discovered between clinical tests and human electrical activity.

The intensity of CMPS symptoms is related to changes in pain, autonomic function, activity of muscles, sensitivity to touch, and muscle activity on both sides of the body. Our research shows that medical history, mood, cultural influences, among other aspects play a major role in the results a patient reports (Dolgin, 2024). Numerous studies suggest that PMR is an inflammatory disorder marked by stiffness, discomfort, and reduced function (Twohig et al., 2022). Results also indicate that therapies such as reducing sensitivity to pain, correcting autonomic imbalances, and governing how much our muscles respond could be effective.

CONCLUSION

Learned from the study, people with CMPS experience distinct neuromuscular and autonomic alterations, as shown by the latest EMG findings. Patients with CMPS experienced much less pressure pain threshold and increased pain during examination, showing they are hyperalgesic. It was shown that MUAP amplitude and duration increased, the mean frequency of the EMG signal decreased, and endplate noise was higher using both high-density surface EMG and intramuscular EMG. According to the study, problems with motor unit performance and continuous electrical activity coming from trigger points were found. Patients with CMPS were also shown to have a higher degree of "internal" synchronisation, which suggests changes in how they control movements due to pain. Moreover, the study found that CMPS is accompanied by an imbalance between the sympathetic and parasympathetic components of the nervous system and reduced heart rate variability. Their high correlation with how severe the pain is indicates that autonomic indicators are significant in treating chronic pain. The matrix showed a strong relationship between pain and sensory, motor, and autonomic measures. From what we can see, this method effectively identifies the physiological features of CMPS. Measurements like these can help with tracking the progress of the illness as well as monitoring the effects of treatment and diagnosis. Thanks to this approach, clinicians can rely on neurophysiological findings when treating chronic myofascial pain and gain a deeper understanding of the issue. The results require confirmation, and we need larger cohorts in future studies to understand how focused therapies influence the field of CMPS.

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