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Research Article

Head Forward Posture and Cervical Joint Position Sense with Electrical Muscle Activity in Upper Cross Syndrome: A Correlational Analysis

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ABSTRACT

Forward Head Posture (FHP) is a functional condition linked to changes in cervical and shoulder muscle activity, and it is well-known that muscle function influences kinesthesia, a key measure of cervical proprioception affecting joint proprioception and overall functionality. However, studies on the electromyographic (EMG) characteristics of FHP and kinesthesia are limited. This study aimed to examine the relationship among kinesthesia, FHP, and EMG characteristics in Upper Crossed Syndrome (UCS) patients. Conducted in the Physiotherapy Department at SGT University in Gurugram, India, 45 UCS patients participated in a three-month cross-sectional study with EMG recordings for 12 bilateral muscles (upper, middle, and lower trapezius; serratus anterior; pectoralis major; anterior scalene). Participants performed Y and W movements with elastic resistance, and kinesthesia was measured using Joint Position Sense Error (JPSE), while FHP was assessed using photogrammetry and a ruler. Pearson's correlation was used to analyze data ($p \leq 0.05$). The result indicated FHP and kinesthetic feeling were found to be statistically substantially linked with the average amplitude of the Upper Trapezius (UT), Lower Trapezius (LT), and Serratus Anterior (SA) ($p \leq 0.05$). Furthermore, a substantial ($p \leq 0.05$) association was found between FHP and the muscle activation ratios of UT: LT and UT: SA. In conclusion, forward head posture and joint position perception are strongly correlated with altered muscle activation in UCS patients.

Keywords: Upper cross syndrome, Foreword head posture, Kinesthesia, Joint Position Sense Error, Electromyography

Abbreviations

Forward Head Posture	FHP
Upper Crossed Syndrome	UCS
Joint Position Sense Error	JPSE
Electromyography	EMG
Upper Trapezius	UT
Middle Trapezius	MT
Lower Trapezius	LT
Serratus Anterior	SA
Pectoralis Major	PM
Anterior Scalene	AS
Craniovertebral Angle	CVA
Root Mean Square	RMS

BACKGROUND

Upper Cross Syndrome (UCS) is a pattern of muscular imbalance first described by Dr. Vladimir Janda, MD (1923–2002). Characterized by specific muscular involvements and postural misalignments, UCS presents as a cross-like configuration when the weakened and shortened muscles in the upper body are mapped (Morris, 2006; Morris, 2015; Clark, 2006). This syndrome results from habitual poor posture and prolonged static positioning, particularly in activities that involve prolonged sitting or forward-leaning postures.

The incidence of UCS is notable, affecting an estimated 11% to 60% of individuals across various age groups and populations (Karimian, 2019). Additionally, forward head posture (FHP), a frequent manifestation of UCS, has a prevalence of approximately 66% among individuals aged 20 to 50 (Griegel-Morris et al., 1992). This altered posture leads to characteristic changes, including thoracic hyperkyphosis, anterior pelvic tilt, and scapular downward rotation, along with an inward rotation of the shoulders. These postural deviations impose significant strain on the musculoskeletal system, potentially increasing the risk of discomfort, dysfunction, and musculoskeletal disorders. Accordingly, understanding the interrelation between UCS-associated postural changes, forward head posture, and muscle activation patterns may provide insights into effective management strategies for individuals with this condition.

Although UCS is a well-recognized musculoskeletal disorder, particularly prevalent in sedentary populations, its precise cause remains idiopathic. Various hypotheses propose that factors such as forward head posture (FHP), rounded shoulders, and anterior pelvic tilt may be associated with UCS; however, no studies to date have comprehensively explored the correlation between FHP and the activation patterns of upper body and periscapular muscles in individuals with UCS (Fathollahnejad, 2019; Falla, 2007). Proprioceptive degradation has been shown to impair movement control and accuracy, affecting the timing and recruitment of motor commands. This degradation can, in turn, influence neck posture, potentially contributing to the development and persistence of FHP in UCS (Arimi et al., 2018).

Given these associations, this study aims to address the need for research on the relationship between kinesthesia, FHP, and the activation patterns of upper body and periscapular muscles in UCS. By exploring these correlations, the study seeks to provide deeper insights into the mechanisms underlying UCS and to inform targeted therapeutic approaches.

MATERIALS & METHODS

PARTICIPANTS AND STUDY DESIGN

This study is designed as a cross-sectional investigation to examine the relationship between forward head posture (FHP), kinesthesia, and the activation patterns of upper body and periscapular muscles in individuals with Upper Cross Syndrome (UCS). A sample of 40 participants was recruited through purposive sampling from the Biomechanics & Research Laboratory at SGT Hospital, where data collection took place.

Participants aged between 18 and 30 years and included both male and female individuals diagnosed with UCS, a condition identified through clinical assessment based on posture and muscle imbalance characteristics. Only subjects who fulfilled all inclusion criteria were selected to ensure consistency across the sample. Specifically, the inclusion criteria required participants to have observable signs of UCS, including forward head posture, rounded shoulders, and muscle tightness in the upper trapezius and pectoralis major. Participants with a history of musculoskeletal injuries to the neck or upper limbs within the past six months were excluded to avoid confounding effects from recent trauma or rehabilitation. Additionally, individuals engaged in professional sporting activities were not considered for inclusion, as repetitive high-intensity physical activities may alter muscle activation patterns and proprioceptive responses, potentially skewing the study outcomes. Finally, any participants with diagnosed neurological deficits were excluded to control for possible impairments in proprioception or muscle activation that might independently influence posture and motor function.

The sample size of 40 participants was determined based on feasibility and prior studies examining similar variables in postural syndrome research. Data collection was conducted in a controlled environment within the Biomechanics & Research Laboratory, allowing for precise assessment and standardized measurements of muscle activation and posture.

The recruitment of subjects is conducted in accordance with the established eligibility criteria for this study. Following recruitment, tests for forward head posture (FHP) and joint position sense (JPS) were administered to all participants. Subsequently, electrode placement was performed, and participants were familiarized with the exercise protocol, which included specific exercises designed to assess muscle activation, namely the Y and W exercises.

OUTCOME MEASURES

The outcome measures for assessing forward head posture (FHP) include the use of a goniometer to evaluate cervical angles, average amplitude (RMS) of muscle activation measured with PowerLab 26T EMG, and kinesthesia assessed through the Joint Position Sense Error (JPSE) test. These tools, taken together, allow a thorough study of FHP-related postural and neuromuscular characteristics.

sEMG

Bipolar silver-silver chloride (Ag-AgCl) surface electrodes (PowerLab 26T, 4-channel electromyograph; ADInstruments) were used to record electromyographic (EMG) data. In accordance with Ekstrom et al.'s recommendations and the SENIAM guidelines for surface EMG electrode placement, electrodes were positioned bilaterally on the pectoralis major (PM), serratus anterior (SA), anterior deltoid (AS), lower trapezius (LT), middle trapezius (MT), and upper trapezius (UT) muscles. For the best signal quality, the inter-electrode spacing was kept constant at 2.0 cm. In order to reduce impedance, the skin covering each muscle was prepped before electrode implantation. If necessary, this required shaving the area and then using an alcohol swab to clear away any remaining debris and oils. A reference electrode was placed over the C7 spinous process to serve as a common ground, consistent with previous studies (e.g., Alenabi, 2018; Brookham, 2016; Chopp-Herly, 2016). This standardization ensured consistent signal integrity across trials. A band-pass filter set between 10 and 1000 Hz was used to process raw EMG signals in order to eliminate low- and high-frequency noise and separate the pertinent frequency components linked to muscle activation. To reduce interference from electrical noise sources, the signals were then differentially amplified at 60 Hz with a common-mode rejection ratio of more than 100 db. To maximize signal fidelity, the amplifier's input impedance was set to 100 MΩ.

A 16-bit analog-to-digital (A/D) converter was used to transform the signals into digital form while sampling was carried out at a rate of 3000 Hz. The A/D converter ensured a high-resolution recording of muscle activity by operating within a range of +/- 10 V. These signal processing parameters provided dependable and high-quality data for further analysis because they were in line with accepted procedures in electromyography investigations on postural and upper limb muscles (e.g., Alenabi, 2018; Brookham, 2016; Chopp-Herly, 2016).

In this study, 100 cm TheraBands (TheraBand Performance Health, Akron, OH, USA) in five colors (yellow, red, green, blue, and black) were utilized, with resistance increasing in the order listed. Participants in the study will use a band with the strongest resistance they can bear while maintaining proper form during the exercise. Overhead action was mimicked with the 'Y' exercise, while underhead activity was imitated with the 'W' exercise.

Fig 1. (A) Y exercise (B) W exercise

KINESTHESIA

The Joint Position Sense Error (JPSE) test was conducted to assess participants' ability to accurately relocate their natural head posture (anatomic position) following active cervical movements. Participants were instructed to perform either cervical extension or rotation to the left and right while blindfolded, ensuring that visual feedback was eliminated during the task.

Data was collected using a laser pointer attached to a lightweight headband. Any deviation from the initial starting location could be precisely measured because the laser beam was directed onto a fixed target that was 90 cm away. The JPSE was defined as the difference between the laser beam's initial starting position and its returning position on the target. The following formula was used to determine this inaccuracy in degrees:

angle = tan -1 [error distance/90 cm].

This approach provided a quantitative measure of proprioceptive accuracy in head positioning, with the error distance serving as an indicator of kinesthetic awareness in cervical joint repositioning.

CRANIO VERTEBRAL ANGLE (CVA)

A goniometer was used to measure the craniovertebral angle (CVA) to evaluate forward head posture (FHP). The goniometer's fixed arm was oriented parallel to the ground, and its axis was oriented in line with the spinous process of the C7 vertebra to acquire precise measurements. The tragus of the ear was then the target of the movable arm. This configuration guaranteed the goniometer's exact alignment for reliable readings. Individuals with a CVA of less than 50 degrees were categorized as having a forward head posture, which is characterized by a prolonged head position with the trunk, based on criteria developed by Ruivo et al. (2016).

DATA ANALYSIS

SPSS version 21 and Microsoft Excel 2010 are used for data analysis. To investigate the correlations between variables and determine their direction and intensity, Pearson's correlation test was utilized. The criterion for statistical significance was established by setting the significance level for all analyses at 95% ($p < 0.05$). This method allowed for a credible comparison of data points by guaranteeing that the results were both rigorous and interpretable within a predetermined confidence level.

RESULT

Table 1. Correlation of Muscle Activation with JPSE

MUSCLE	JPSE (R- value)	JPSE (P-value)
YRUT	-0.699	0.0001
WRUT	-0.822	0.0001
YRMT	-0.693	0.0001
WRMT	-0.786	0.005
YRLT	-0.533	0.017
WRLT	-0.5	0.031
YRSA	0.211	0.862
WRSA	0.496	0.368
YRPM	-0.448	0.091
WRPM	-0.585	0.055
YRAS	-0.511	0.003
WRAS	-0.243	0.765
YLUT	-0.192	0.418
WLUT	-0.600	0.005
YLMT	0.166	0.483
WLMT	-0.608	0.004
YLLT	-0.325	0.163
WLLT	-0.102	0.669
YLSA	-0.451	0.046
WLSA	-0.108	0.649
YLPM	-0.111	0.642
WLPM	-0.203	0.390
YLAS	-0.359	0.120
WLAS	-0.64	0.002

Table 2. Correlation of muscle activation with FHP

MUSCLE	FHP (R- value)	FHP (P- value)
YRUT	0.804	0.001
WRUT	0.81	0.0001
YRMT	0.829	0.001
WRMT	0.599	0.0001
YRLT	0.526	0.015
WRLT	0.482	0.025
YRSA	0.042	0.372
WRSA	-0.213	0.026

YRPM	0.388	0.048
WRPM	0.435	0.007
YRAS	0.625	0.021
WRAS	0.071	0.302
YLUT	-0.048	0.842
WLUT	0.342	0.140
YLMT	-0.005	0.985
WLMT	0.533	0.016
YLLT	0.397	0.083
WLLT	0.156	0.511
YLSA	0.489	0.029
WLSA	0.256	0.276
YLPM	0.072	0.764
WLPM	-0.016	0.947
YLAS	0.474	0.035
WLAS	0.605	0.005

YRUT: Y Exercise, Right Upper Trapezius
WRUT: W Exercise, Right Upper Trapezius
YRMT: Y Exercise, Right Middle Trapezius
WRMT: W Exercise, Right Middle Trapezius
YRLT: Y Exercise, Right Lower Trapezius
WRLT: W Exercise, Right Lower Trapezius
YRSA: Y Exercise, Right Serratus Anterior
WRSA: W Exercise, Right Serratus Anterior
YRPM: Y Exercise, Right Pectoralis Major
WRPM: W Exercise, Right Pectoralis Major
YRAS: Y Exercise, Right Anterior Deltoid
WRAS: W Exercise, Right Anterior Deltoid
YLUT: Y Exercise, Left Upper Trapezius
WLUT: W Exercise, Left Upper Trapezius
YLMT: Y Exercise, Left Middle Trapezius
WLMT: W Exercise, Left Middle Trapezius
YLLT: Y Exercise, Left Lower Trapezius
WLLT: W Exercise, Left Lower Trapezius
YLSA: Y Exercise, Left Serratus Anterior
WLSA: W Exercise, Left Serratus Anterior
YLPM: Y Exercise, Left Pectoralis Major
WLPM: W Exercise, Left Pectoralis Major
YLAS: Y Exercise, Left Anterior Deltoid
WLAS: W Exercise, Left Anterior Deltoid

The correlation results show that there are different levels of association between each muscle group and both Joint Position Sense Error (JPSE) and Forward Head Posture (FHP). During both the Y (-0.699, p=0.0001) and W (-0.822, p=0.0001) exercises the Upper Trapezius results demonstrate a substantial negative connection between muscle activation and JPSE, suggesting that higher activation is linked to lower joint position sense error. Furthermore, Y (0.804, p=0.001) and W (0.81, p=0.0001) exercise show a strong positive connection with FHP, indicating a relationship between elevated activation levels and forward head posture. The Middle Trapezius also showed substantial positive relationships with FHP during the Y (-0.693, p=0.0001) and W (-0.786, p=0.005) exercises, and strong negative relations with JPSE. Like this, the Middle Trapezius showed moderate correlations with FHP during W (0.599, p=0.0001) and high positive correlations with FHP during Y (0.829, p=0.001), as well as substantial negative correlations with JPSE for both Y (-0.693, p=0.0001) and W (-0.786, p=0.005) exercise.
Moderately negative correlations with JPSE were noted for the Lower Trapezius during the Y (-0.533, p=0.017) and W (-0.5, p=0.031) exercises, whereas correspondingly moderately positive correlations with FHP were noted during Y (0.526, p=0.015) and W (0.482, p=0.025) activities. While the Serratus Anterior's association with FHP was erratic, with weak correlations seen during Y (0.042, p=0.372) and W (-0.213, p=0.026), it had weak or non-significant correlations with JPSE, with values during Y (0.211, p=0.862) and W (0.496, p=0.368). Weak negative correlations between the Pectoralis Major and JPSE were observed during the Y (-0.448, p=0.091) and W (-0.585, p=0.055) exercise. It had a weak to moderate connection with FHP, with values during Y (0.388, p=0.048) and W (0.435, p=0.007), indicating a small but significant effect in posture. Its

positive correlations with FHP were strong during Y (0.625, p=0.021) and weaker during W (0.071, p=0.302), suggesting a stronger relationship with posture in Y exercise. In contrast, the Anterior Deltoid showed moderate negative correlations with JPSE during Y (-0.511, p=0.003) and W (-0.243, p=0.765).
Overall, the results point to the significance of the trapezius muscles in postural control and sensorimotor function, with the upper and middle parts of these muscles showing the strongest relationships with both JPSE and FHP. The involvement of other muscles, including the pectoralis major, anterior deltoid, and serratus anterior, varied, with their contributions being evident physical activity or characteristics.

DISCUSSION

The present study investigated the relationship between muscle activation, joint position sense errors (JPSE), and forward head posture (FHP) in individuals with upper cross syndrome (UCS). The findings indicate a negative correlation between muscle activation in both overhead and underhead activities with JPSE, and a positive correlation with FHP on the dominant side (right). Specifically, as muscle amplitude increases, JPSE errors decrease, and the cervical-vertebral angle (CVA) increases. This suggests that greater muscle activation is associated with improved joint position sense, which may contribute to better postural control and alignment, particularly in individuals with UCS.
The relationship between muscle activation and JPSE aligns with the concept of proprioceptive feedback, where increased amplitude indicates greater neuromuscular engagement, likely enhancing sensory-motor integration. This improved activation may facilitate more accurate joint position sense, thus reducing errors in perception (JPSE). Conversely, the dominant side in UCS exhibited lower muscle contractility, particularly due to an increase in resting amplitude, leading to a diminished ability of the primary muscles to generate force. This muscle weakness is compounded by the length-tension relationship, which states that muscles operating at lengths far from their optimal resting point experience reduced contractile force. As the primary muscles (such as the deep cervical flexors) are unable to generate sufficient force to stabilize the cervical spine, accessory muscles (such as the upper trapezius and sternocleidomastoid) compensate by engaging in abnormal muscle recruitment patterns.
This compensation results in trick motions or altered movement strategies that exacerbate the forward head posture seen in UCS. These compensatory mechanisms further contribute to muscle imbalance, affecting the postural alignment of the cervical spine and leading to the characteristic rounded shoulders and anterior head carriage. The positive correlation between FHP and muscle activation on the dominant side reinforces the idea that FHP is not simply a postural deviation but a dynamic process driven by altered neuromuscular control. This altered control may be indicative of maladaptive motor patterns arising from insufficient muscle activation in the deep cervical flexors and over-reliance on accessory muscles.
Furthermore, the current study's findings are consistent with previous research that has pointed to the detrimental effects of impaired proprioception in individuals with neck pain and UCS. Choi (2021) and others have noted that abnormal cervical afferent input—resulting from muscle weakness or dysfunction—leads to impaired joint position sense, particularly in individuals with cervical spine issues. This finding supports the observed relationship between reduced muscle contractility and increased FHP and the presence of JPSE errors. As cervical afferent input is disrupted, the brain's ability to accurately perceive the position of the head and neck is compromised, exacerbating postural abnormalities such as FHP.
In line with these findings, it is important to note that the reduced contractility in the dominant side of the UCS participants may also be related to asymmetric muscle activation patterns. The dominant side of the body is often subject to increased demands during daily activities, leading to muscle fatigue, overuse, and ultimately, reduced contractile capacity. Over time, this could create a vicious cycle in which the primary stabilizing muscles become progressively weaker, further contributing to abnormal muscle recruitment and postural misalignment. The association between dominant-side muscle weakness and FHP further emphasizes the need for targeted interventions that address these muscle imbalances, particularly in the deep cervical flexors.
Moreover, the length-tension relationship observed in this study has important implications for rehabilitation strategies. The inability of the primary muscles to produce adequate force, due to their altered resting length, necessitates the use of therapeutic interventions aimed at improving both muscle length and strength. Stretching exercises and strengthening programs focused on the deep cervical flexors and other key stabilizing muscles of the upper cervical region may help restore optimal muscle length-tension relationships, improve force generation, and ultimately reduce compensatory patterns that lead to FHP.

CONCLUSION

This study demonstrates the strong relationship between muscle activation patterns, joint position sense error (JPSE), and forward head posture (FHP) in people with Upper Cross Syndrome (UCS). The results show that better proprioception and lower JPSE are linked to enhanced muscle activation during overhead and underhead movements, namely in the upper and lower trapezius and serratus anterior. On the other hand, because of compensatory muscle recruitment patterns, FHP gets worse by altered neuromuscular activation and decreased contractility on the dominant side. These findings highlight how proprioceptive function, muscular activation, and postural control interact dynamically in UCS. To effectively treat UCS and its associated dysfunctions, rehabilitation programs should give priority to interventions that improve proprioception, restore optimum muscle activation, and address postural imbalances.

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