

Introduction

1.1 Introduction

Muscle fatigue is a common health issue in medical practice, which is increasing day by day due to people's unhealthy lifestyle. It can be defined as a reduction in the physical ability of the muscle to produce force. It results in loss of energy, exhaustion, reduced mental and physical alertness, and often accompanied by drowsiness [Wan et al., 2017; Gruet, M. et al., 2013]. The non-invasive detection of muscle fatigue has become a serious concern in the fields of sports injuries, rehabilitation, ergonomics, and prosthetics. Electromyography (EMG) and mechanomyography (MMG) are the two techniques which frequently utilized for automated fatigue detection [Al-Mulla et al., 2012].

Muscle fatigue may be considered to have several measurements peripheral, central, mental, physical, etc. Peripheral fatigue is used to describe muscle fatigability due to disorder of the neuromuscular junction transmission [Chaudhuri et al., 2004]. Physical weakness is the human experience of tiredness following physical effort and is distinguishable from central fatigue. Central fatigue originates at the central nervous systems (CNS), which decrease the neural drive to muscle [Bigland-Ritchie et al., 1978; Gandevia 2001]. Mental fatigue refers to the cognitive or perceptual aspects of fatigue [Wan et al., 2017; Berrios, et al., 1990; Gruet, M et al., 2013].

Fatigue can be classified as acute fatigue and chronic fatigue. Acute fatigue can be quickly relieved by rest, whereas chronic fatigue is defined as persistent tiredness over months that is not improved by rest. [Norheim et al., 2011; Kroenke et al., 1988].



Figure 1.1 Muscle Fatigue

Nowadays, Neck pain (NP) is the most common problem of our day to day life [Hoving et al., 2002]. More than 70% of middle-aged individuals are getting suffered from neck pain disorder. The main reasons for neck pain are poor posture, anxiety, depression, sporting activities, and other stressful situations [Peterson et al., 2002].

Neck pain can be caused due to disorders, which include cervical facet syndrome, neck strain, and degenerative disc disease [Jensen and Harms-Ringdahl, 2007]. It is generally associated with paraspinal neck muscle, cervical radiculopathy, and cervical spondylosis.



Figure 1.2 Neck pain

1.2 Classification of Neck Pain

Neck pain can be classified as follows

- **Axial neck pain:** Axial pain is Musculoskeletal, and is pure neck or soft tissue pain. Whiplash or muscle strain is an example.
- **Radiculopathy:** Cervical radiculopathy refers to neck and arm pain due to nerve root compression. Symptoms include arm pain, numbness, or weakness.
- **Myelopathy:** Myelopathy refers to pressure on the spinal cord, also referred to as spinal cord compression. Symptoms include neck pain with arm or leg weakness, numbness, or walking problems [Rao, Raj, 2002].

1.3 Motivation and Problem Statement

Neck pain is caused due to bad sitting posture, continuous and uneven development of stress, which takes place across the neck muscle, resulting in fatigue in the neck muscles. Precise analysis of the EMG signal provides detailed information about muscle activity. The EMG signal features are significantly affected by the occurrence of muscle fatigue condition. Therefore in this work, EMG data were recorded for the various subjects suffering from neck pain to analyze their muscle fatigue status.

Medical officer often refers to patients suffering from neck pain to the physiotherapy department for medical care. Traction therapy is the common and frequent technique used by the physiotherapists for the management of neck pain. Based on their knowledge and experience, physiotherapists decide the intensity and duration of traction treatment. Therefore, before giving traction treatment to patients, prior and detailed information about the neck muscle fatigue analysis is important.

In this work, for EMG data analysis of various patients suffering from neck pain during cervical traction treatment is being recorded using a wireless EMG sensor. For analysis, the time-domain and frequency-domain features were extracted from the acquired EMG signal. The time-domain features are mean absolute value (MAV), root mean square (RMS), and standard deviation (SD). The calculated RMS and MAV value helped in effectively assessing muscle fatigue and frequency domain features as mean frequency (MF) and median frequency (MDF) are also essential features of muscle fatigue analysis.

This study quantifies the efficacy of mechanical cervical traction used for the treatment of neck pain.

1.4 Objectives of the thesis

This research work aims to do the quantitative analysis of neck muscle fatigue during cervical traction treatment using a wireless EMG sensor.

The following are the specific objectives:

- (i) Quantitative analysis of radiculopathy patients under cervical traction treatment using EMG data.
- (ii) To evaluate the efficacy of mechanical cervical traction for cervical spondylosis patients using time-frequency features.
- (iii) Clinical assessment of muscle fatigue using LabVIEW.
- (iv) To evaluate the classification of EMG data to assess the fatigue level of the different subjects while providing traction therapy over a certain period.

1.5 Outcome of the Thesis

The main outcomes of this research work the quantitative analysis of neck muscle fatigue during cervical traction treatment. The outcomes are given below:

- In this work, two groups of patients, one group having neck pain with radiculopathy, and other groups having neck pain without radiculopathy, patients undergone cervical traction treatment using a wireless EMG sensor. The acquired EMG data was used to extract various features of neck muscles in the time domain (MAV RMS, and SD) and frequency

domain (MF and MDF) features for the assessment of neck muscle fatigue. The extracted features showed a significant difference in muscle activity in both groups.

- In this work, the statistical analysis of neck pain and spondylosis pain patients was performed. From the recorded EMG data, the time and frequency domain features were extracted. The statistical significance test was conducted and the result showed significant changes in the features from the first day to the last day.
- In this work, the algorithm was implemented in the LabVIEW showing the fatigue relaxation status on the front panel window from the uploaded pre and post EMG data of the subject. This method decreases the computation time for fatigue detection. This study concluded the effectiveness of traction therapy in the reduction of neck pain in various patients.
- In this work, the classification of EMG features was done to analyze the fatigue level of various neck pain patients during traction therapy. The support vector machine and complex tree classifier have been used to assess the classification performance. It was found that the accuracy of the support vector machine is higher than the complex tree. Similarly, the kappa value is high as compared to a complex tree.