# Chapter 2
# Literature Survey

## 2.1 Introduction

This chapter presents a brief overview of the existing literature that mainly confers the fundamental concepts of neck muscle fatigue analysis using electromyography (EMG) data. This section critically reviews the available neck muscle fatigue determining techniques, their comparison.

Previous research works highlight the study of different types of problems, such as neck pain, cervical radiculopathy, and spondylosis pain. The survey was done in the framework of different types of traction treatment for the reduction of neck pain. Moreover, a survey regarding the analysis and classification of EMG data from neck muscle is also described in this chapter.

## 2.2 Muscle Fatigue

Muscle fatigue is defined as a decrease in the performance of muscle strength and is caused by various physical, biochemical, nutritional, and environmental factors. It is broadly classified into three groups: (i) subjective fatigue, which is influenced by psychological factors such as lack of motivation, (ii) physical fatigue, which manifests itself by changes in physiological process, and (iii) objective fatigue, which shows a decline in productivity [Chaffin 1973]. In another approach, muscle fatigue is also classified as central and peripheral fatigue. Central fatigue originates from the central nervous system, which decreases the neural drive of the muscle, whereas peripheral fatigue affects the distal end of the muscle or at the neuromuscular junctions [Gandevia et al., 2001; Bigland-Ritchie et al., 1978].

### 2.2.1 Neck Pain

Neck pain is a common and disabling problem in the general population. The main causes of neck muscle pain are poor posture, anxiety, depression, muscle strain, and sporting activities [Vernon H et al., 2007; Peterson et al., 2002]. Neck pain is noticed in all sections of the population regardless of physical activity level [Hogg-Johnson et al., 2008; Cote et al., 2008]. Neck pain comes from many disorders and includes cervical facet syndrome, neck strain, degenerative disc disease [Jensen and Harms-Ringdahl, 2007], etc.

Neck muscle fatigue analysis is discussed here, including current challenges in this domain.

### 2.2.2 Methods of Neck Pain Reduction

There are various methods of neck pain reduction, as follows:

- **Physical Therapy:** Physical therapy methods are used to reduce neck pain and stiffness. The duration of the treatment plan can vary from person to person.
- **Traction:** Traction uses weights, pulleys, or an air bladder to stretch the patient's neck. This therapy, under the supervision of a medical profession and physical therapist, may provide relief in neck pain. It has become a standard practice of physiotherapists to refer to patients suffering from neck pain to undergo cervical traction therapy.
- **Acupuncture:** Acupuncture involves the insertion of thin needles into various points on the patient's body. Using needles, an experienced acupuncturist will target areas of pain to give complete pain relief without medications.

- **Chiropractic care:** Chiropractic care is a non-surgical treatment that reduces neck pain and stiffness. Practitioners use their hands to treat muscle, joint, and nerve pain by adjusting the spine and joints.
- **Pain Management Methods:** There are pain management methods that require drugs with heavy side effects or severe surgery [Neck pain - Diagnosis and treatment - Mayo Clinic, 2019].

Cervical Traction treatment is the most commonly prescribed therapy by doctors for the management of neck pain.

## 2.3 Cervical Traction

Traction is one of the oldest methods of therapy known and has been employed in a variety of forms to relieve pain and discomfort since ancient times [Hooper, 1996]. In cervical traction treatment, stretching of the spine is done to isolate the vertebrae to relax the neck muscles. It is used for the treatment of cervical spine injuries, including cervical herniated disc, radiculopathy, strain, and spondylosis. The traction machines comprise adjustable weights for applying strain to the neck at different intensities. The pulling time of traction on the level is decided based on neck pain. There are various approaches for applying cervical traction to the neck [Wong et al., 2017].

Manual cervical traction is done by a physical therapist. In mechanical traction, treatment is given by an instrument, and Gravitational Traction: Gravity provides the distraction force.


**Figure 2.1** Cervical Traction

According to [Hooper, 1996], suggested that the therapist begins with a traction force of (4.5 kg to 7 kg) tension. It is the safe and effective application of traction to the cervical spine. [Saunders, 1983] use of spinal traction in the treatment of neck condition and found that weights of 8 kg to 20 kg were necessary to demonstrate a measurable change in the posterior cervical spine structures.

## 2.4 EMG (Electromyography)

Electromyography (EMG) refers to the collective electric activity from muscles, which is controlled by the nervous system and produced during muscle contraction. It is a non-invasive procedure used to amplify, display, and record electrical activity in the muscles [Merletti et al., 2009; Chowdhury et al., 2013].

EMG signal is produced by physiological variation in the state of muscle fiber membranes during voluntary and involuntary contractions. The surface EMG signal has amplitude ranging from 0 to 10 mV (peak to peak), and frequency range lies between 0 to 500Hz [Anjana Goen et al., 2013].

The extracted information from EMG data is useful in different fields, rehabilitation medicine, ergonomics, physiotherapy, sports medicine, neurophysiology, and kinesiology.

EMG data is also used for muscle fatigue analysis; the parameters usually used are amplitude and frequency of the signal. [De Luca, 1993; Thelen et al., 1994; Gottlieb and Agarwal, 1977; Valero-Cuevas et al., 2003]. The various features for muscle fatigue analysis are: mean absolute value, root mean square, standard deviation, and variance. These are commonly used features in time domain analysis [Phinyomark et al., 2009]. Time-domain features are frequently used as a muscle force detection tool. To analyze the frequency component of the EMG signal, the mean and median frequencies are the most important parameters [Thongpunja et al., 2013].

The wireless EMG sensor is used in a recording of EMG data. The distance is 40 meters is utilized to get the information from EMG sensors. [Dong H. et al., 2014].

A lot of research has been done for the assessment of neck pain, which is described below.

| S. No. | Authors (Years) | Objectives | Conclusions |
|---|---|---|---|
| 1. | Deets et al. (1977) | This study compared the EMG data for sitting and supine positions during traction treatment. | The result indicated that the supine position was more useful in the treatment of the cervical spine with traction. |
| 2. | DeLacerda (1980) | Determined the effect of varying angles of intermittent cervical traction of fixed force magnitude on the EMG activity of a selected muscle. | Statistical analysis revealed that a positive relationship existed between an increase in the angle of pull and muscle activity |
| 3. | Jette et al. (1985) | Compared the muscle activity in the upper trapezius muscle before, during, or after supine cervical traction. | No significant differences in muscle activity were found at different time periods. |
| 4. | Murphy et al. (1991) | Compared the EMG activity in both normal and pain subjects before, during, and after cervical traction treatment. | No significant difference between group ($P>0.05$) noted in EMG recordings at rest and within 10 minutes of traction. So the cervical traction does not produce muscular relaxation as measured with EMG equipment. |
| 5. | Van der (1995) | Assessed the efficacy of traction for patients with neck or back pain. | Observed no traction modality for back or neck pain is effective, or more effective than other treatments. There are no clear indications; however, that traction is an effective therapy for back and neck pain. |
| 6. | Wong et al. (1997) | The design of cervical traction modality with closed-loop traction weight control based on EMG biofeedback was developed. | No significant change of muscle activity in the paraspinal muscle at vertebral levels C1-2, C3-4, and C5-6. |
| 7. | Krause et al. (2000) | This study reviewed which traction benefits and to provide guidelines for the clinical application of traction. | Found that traction has been shown to separate vertebrae, stretch the cervical joint capsules, stretch neck muscles, and open the foramina. |

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| 8. | Korthals -de Bos et al. (2003) | Evaluated the cost effectiveness of physiotherapy, manual therapy and care by a general practitioner for patients with neck pain. | The result showed that the manual therapy is more effective and less costly for treating neck pain than physiotherapy or care by general practitioner. |
| 9. | Graham et al. (2006) | Analyzed the effect of mechanical traction for a neck disorder. | No statistically significant difference between continuous traction and placebo traction in reducing pain or improving function for a chronic neck disorder. |
| 10. | Ylinen et al. (2007) | Compared the effects of manual therapy and strengthening exercise on neck pain and disability. | Both strengthening exercise and manual therapy considerably decreased both Neck pain and disability. |
| 11. | Borman et al. (2008) | This study examined the efficacy of traction therapy in chronic neck pain. | No effect of traction over physiotherapeutic interventions was observed in adults with chronic neck pain. |
| 12. | Fater et al. (2008) | Compared the magnitude of cervical vertebral separation during cervical traction in supine and seated positions using home traction units. | No significant changes in anterior vertebral separation during either supine or seated traction position. |
| 13. | Chiu et al. (2011) | This study examined the efficacy of cervical traction in the treatment of neck pain over a 12 week followed up. | No significant difference in between the two groups in the neck pain questionnaire ($P > 0.05$), verbal numerical pain scale ($P > 0.05$) and cervical active range of motion ($P > 0.05$). |

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| 14. | Dawood et al. (2013) | The purpose of this study was to compare the effects of Kinesio taping and cervical traction posture pump on MND. | Observed that Kinesio taping cervical traction posture pump is equally effective in improving cervical curvature, pain intensity, and function neck disability in patients with mechanical neck disorders compared to exercise program alone, which was the least effective. |
| 15. | Khosravani et al. (2013) | Evaluated the efficiency of applying a number of techniques which have been mostly used to detect muscle fatigue in isometric contraction and isotonic contraction. | The calculation of EMG features (RMS and median frequency; the situation which resulted in considerable differences in the quantities of the calculated values. |
| 16. | Bid et al. (2014) | Determined the effectiveness of cervical traction in the management of mechanical neck pain. | The pre-test evaluation showed that there is no significant difference ($P>0.05$) between the two groups for all the variables measured. The post-test evaluation of both groups showed a significant difference within the groups. They conclude that conventional therapy is effective for pain reduction and neck disability. |
| 17. | Bosmia et al. (2015) | Compared the effectiveness of manual mulligan traction (MT) with intermittent electric (IET) in the subject having cervical spondylosis. | This study showed significant improvement in range of motion (ROM) of the subjects treated with MT. However, the other parameters (NRS & NDS) did not show any significant changes. This paper concluded that Manual mulligan traction (MT) is more efficient than intermittent electric traction (IET) in cervical spondylosis. |

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| 18. | Hoseinp – our et al. (2015) | Analyzed the three different methods (physiotherapy with cervical traction, acupuncture, and strengthening exercise) for three weeks. | This paper indicated that physiotherapy with traction is useful than needle therapy and strengthening exercise in patients with cervical disease. After some weeks, traction therapies were more effective in decreasing pain. |
| 19. | Ali et al. (2015) | This study compared the manual therapy with cervical traction in reducing cervical pain and disability. | This paper indicated that cervical mobilization is more effective than cervical traction, both in terms of reducing pain and disability in subjects with non-specific neck pain. |

### 2.4.1 Conclusion

This literature survey discusses the application of electromyography for analyzing neck pain occurring to patients. Also, the different modalities of traction therapy for neck pain treatment were drawn in this chapter. For most of the case studies, the effect of traction therapy was found insignificant in reducing the neck pain of subjects. A quantitative analysis of EMG data recorded for neck muscle required to achieve the positive impact of traction therapy for reducing neck pain.

## 2.5 Cervical Radiculopathy

Cervical radiculopathy is a clinical condition resulting from compression of the cervical nerve roots. The main symptoms of cervical radiculopathy are pain that spreads into the arm, neck, upper back, shoulders, numbness, tingling [Sharma et al., 2014].

| S. No. | Authors (Years) | Objectives | Outcomes |
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| 1. | Moeti (2001) | This study analyzed the effectiveness of intermittent cervical traction treatment on fifteen patients with cervical radiculopathy and neck disability. | In this case, patients with radicular symptoms for 12 weeks and less demonstrated a reduction in pain and disability. |
| 2. | Joghataei et al. (2004) | Determined the effects of cervical traction combined with conventional therapy on grip strength on patients with cervical radiculopathy. | Cervical traction combined with electrotherapy and exercise produced an immediate improvement in the hand grip function in patients with cervical radiculopathy. |
| 3. | Cleland et al. (2005) | Investigated the effectiveness of manual physical therapy, cervical traction, and strengthening exercise in a homogeneous group of patients with cervical radiculopathy. | Described the patients with cervical radiculopathy treated with the multimodal treatment approach of manual physical therapy, the strengthening exercise, and cervical traction reduced pain and improved function at the time of discharge and a six month follows up. |
| 4. | Cleland et al. (2007) | The purpose of this study was to Identify variables from the baseline examination or physical therapy intervention received could predict clinical outcomes for people with cervical radiculopathy. | The result suggested that a subset of predictor variables can accurately identify which people with cervical radiculopathy are likely to experience short term successful outcomes. |
| 5. | Young et al. (2009) | This study was to examine the effects of manual therapy and exercise with or without the addition of cervical traction on pain and disability in patients with cervical radiculopathy | Observed mechanical cervical traction to a multimodal treatment program of manual therapy and exercise yields no significant additional benefit to pain, function, or disability in patients with cervical radiculopathy. |

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| 6. | Ragonese et al. (2009) | Determined the treatment method to produce superior outcomes for patients with cervical radiculopathy: manual physical therapy, therapeutic exercise, or a combination of manual physical therapy and therapeutic exercise. | Significant differences in treatment effects were observed for the reduction of pain, an increase in score on the NDI. |
| 7. | Elnaggar et al. (2009) | This study compared the efficacy of intermittent cervical traction and continuous cervical traction of neck pain and arm pain severity, amplitude, and latency of H reflex of flexor carpi radials muscle and neck mobility in patients with C6 and C7 radiculopathy. | The result showed that there was a significant difference between groups concerning neck frontal and transverse mobility in favor of intermittent traction. |
| 8. | Forbush et al. (2011) | Described the management of 10 patients with advanced cervical spondylarthrosis with radiculopathy, using manual therapy, intermittent traction and home exercise. | This study Concluded that intervention resulted in substantial improvement in numeric pain rating scale and neck disability index (NDI). |
| 9. | Umar et al. (2012) | Compared the effectiveness of traction with muscle-strengthening exercise to traction alone in its management. | This study concluded that the core muscle strengthening exercises an important part in the treatment of Cervical radiculopathy when combined with cervical traction. |
| 10. | Ojoawo et al. (2013) | Evaluated the efficacy of continuous cervical traction on radiating neck pain. | It was concluded that cervical traction is effective in relieving radiating pain and its associated disability. |
| 11. | Rai et al. (2013) | Analyzed the effectiveness of cervical traction, along with conventional therapy in the management of cervical radiculopathy. | Found that exercises and intermittent cervical traction is efficient in the treatment of cervical radiculopathy and must have a considerable position in the management of cervical radiculopathy. |

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| 12. | Sharma and Patel (2014) | This study presented the effectiveness of TENS versus intermittent cervical traction among patients with cervical radiculopathy is sparse. | Found that TENS was more efficient in the management of cervical radiculopathy along with isometric neck exercise in reducing both neck and arm pain. |
| 13. | Angela et al. (2015) | Evaluated the effectiveness of cervical traction, along with conventional therapy in the management of cervical radiculopathy. | The result of this study revealed that both groups a highly significant improvement in as measured by NPRS and decreasing neck disability and improving functional activities as measured by NDI. |
| 14. | Bukhari et al. (2016) | Determined the effects of mechanical versus manual traction in manual physical therapy combined with segmental mobilization and exercise therapy in the physical therapy management of patients with cervical radiculopathy. | This study concluded that cervical radiculopathy treated with mechanical traction, segmental mobilization, and exercise therapy will manage pain and disability more effectively then treated with manual traction, segmental mobilization, and exercise therapy. |
| 15. | Sarfaraj and Deepali (2018) | The purpose of this study was to find out the effects of manual and mechanical cervical traction with neural mobilization (ULTT-1) n cervical radiculopathy. | The outcome of this study showed that there is no significant difference between manual and mechanical traction with neural mobilization in decreasing pain and improving ROM in patients with cervical radiculopathy. |

### 2.5.1 Conclusion

This literature review is to present a comprehensive summary of the management of cervical radiculopathy. The review of modalities used by the physiotherapist in the treatment of neck pain was presented there. The conclusion of this review shows the effectiveness of different types of treatment in relieving neck pain in the case of cervical radiculopathy patients. So there is a need to do quantitative analysis of neck muscle fatigue throughout cervical traction.

## 2.6 Cervical Spondylosis

Cervical spondylosis is a disorder of age-related wear affecting the discs and vertebrae of the cervical spine. Cervical spondylosis is also called cervical osteoarthritis. The common symptoms are neck stiffness, headache, dizziness, abnormal reflexes, muscle spasm [Wang C et al., 2016; Hafez, A. R., 2009].

The previous research work done regarding the analysis and treatment of cervical spondylosis is discussed as follows.

| S. No. | Authors (Years) | Objectives | Outcomes |
|---|---|---|---|
| 1. | Martha L. (1989) | This study was to determine a correlation exist between therapist body weight and the amount of force when using a manual traction technique. | The results indicated a positive correlation between therapist body weight and traction force imparted to the cervical spine when using a manual traction technique. |
| 2. | Nanno M. (1994) | Determined the effectiveness of cervical traction on neck pain and shoulder pain. | Indicated the cervical traction is effective in relieving pain, increasing the frequency of the myoelectric signal, and improving blood flow in affected muscles. |

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| 3. | Jordan et al. (1998) | Compared the effectiveness of intensive training of the cervical musculature, a physiotherapy treatment, and chiropractic treatment on this patient group. | In this study, Primary outcome measures included self-reported pain, disability, medication use, perceived effect, and physician's global assessment. Secondary outcome measures included an active range of motion of the cervical spine as well as strength and endurance measurements of the cervical musculature. These groups showed significant improvement regarding self-reported pain and disability on completion of the study. |
| 4. | Banato et al. (2001) | Proposed a technique for calculating spectral parameters from the surface myoelectric signal during cyclic dynamic contractions. | A comparison of the instantaneous mean and median frequency parameters was reported for the assessment of localized muscle fatigue during dynamic contractions. |
| 5. | Hoving et al. (2002) | Determined the effectiveness of manual therapy, physical therapy, and continued care by a specialist. | This paper concluded that manual therapy is a favorable treatment for neck pain patients compared with physical therapy and continued care by a practitioner. |
| 6. | Atteya, (2004) | This study was to investigate the effect of cervical traction modality with and without electromyography biofeedback for neck muscles in patients with cervical radiculopathy. | This paper reported the different phases of cervical traction showed a significant decrease in EMG activity during the pull period of traction and after traction. |
| 7. | Reddy et al. (2012) | The objective of this study was to analyze whether neck muscle fatigue exercise alerts proprioception and neuro− muscular control of the cervical spine. | This paper outcome shows that improving the functional capacity of these muscles play an essential part in maintaining cervical position sense. |

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| 8. | Akinbo et al. (2013) | Investigated the cardiovascular responses and side effects during cervical traction in sitting and supine positions and also to compare the effects of both positions on pain and neck mobility in spondylosis patients. | The effectiveness of the two traction positions in terms of pain relief and enhance neck mobility in the subject studied. But the supine position recorded a higher mean difference. |
| 9. | Julie M. et al. (2014) | Examined the efficacy of cervical traction, in addition, to exercise for a specific subgroup of patients with neck pain. | The primary analysis examines 2− way treatments by time interactions. Secondary analyses examined the validity of the subgrouping rule by-adding 3− way interactions. This paper outcome that mechanical traction to exercise for patients with cervical radiculopathy resulted in lower disability and pain. |
| 10. | Shah et al. (2015) | Determined the effects of spinal mobilization with and without manual traction on pain and disability in patients with cervical radiculopathy. | Observed that spinal mobilization combined with manual traction is more effective than spinal mobilization alone for the management of radicular pain and disability in patients with cervical radiculopathy. |
| 11. | Choi, J.H et al. (2016) | Studied the changes in the activity and fatigue of the splenius capitis and upper trapezius muscle, the muscles that support the head, under the three postures adopted most frequently while using a smartphone. | The result showed that the comparison of muscle fatigue among the posture showed a statistically significant difference for the right trapezius capitis, left splenius capitis, and left upper trapezius. |
| 12. | Qayyum et al. (2017) | Compared the mechanical traction and manual therapy for relieving pain in patients of cervical spondylosis C5-C6. | The results showed that the p-value for NPRS using mechanical traction was 0.027, which is less than the level of significance 0.05. |

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| 13. | Wong et al. (2017) | Described the development of a cervical traction therapy simulation model that evaluates two types of traction position, namely the sitting position and inclined position. | The result indicated that the inclined position may be more effective in increasing intervertebral separations than the sitting position. |

### 2.6.1 Conclusion

This section has highlighted some aspects of cervical spondylosis pain. The review was done in the different types of traction used by the physiotherapist for reducing neck pain. The effects of traction therapy have also been highlighted for the treatment of cervical spondylosis pain.

## 2.7 Classification

Classification is a supervised learning approach in which the computer program learns from the data input given to it and then uses this learning to classify new observations [Scott et al., 1988].

| S. No. | Authors (Years) | Objectives | Outcomes |
|---|---|---|---|
| 1. | Kamarud din et al. (2005) | Analyzed the detection, processing, and classification of surface EMG signals for the assessment of muscle fatigue | In this work, several indices in time, frequency, and time-frequency representations have been identified for the assessment of muscle fatigue. |
| 2. | Subasi et al. (2010) | The aim of this study was to detect fatigue of biceps brachia muscle using time frequency methods and independent component analysis (ICA). | In this study, Time-frequency methods have been used as a feature extraction method and, ICA has been used to reduce the dimension of feature vectors. Then extracted features of EMG signals have been used as an input to MLPNN that could be used to detect fatigue. |

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| 3. | Xiadong Xu et al. (2014) | Presented an improved incremental training algorithm based on an online support vector machine (SVM). The wavelet transform feature was used to study the changes in EMG when muscle fatigue occurs. | Analyzed the muscle fatigue in EMG and proposed an improved incremental online training algorithm that can be applied to an EMG based HMI system. |
| 4. | Ozmen et al. (2017) | The study compared the classification performance of cervical disc herniation patients with healthy persons by using EMG features. | The result of this study, the Autoregressive method (AR) method, provided the best classification accuracy for the trapezius muscle, and (Discrete wavelet transform) DWT gave the best classification accuracy for the Stermocleidomastois (SCM) muscle. |
| 5. | Karthick et al. (2018) | This study compared the time− frequency features using classifier performance. | The proposed time-frequency distributions are able to show the nonstationary variations of the EMG signal. Most of the features statistically significant differences in muscle fatigue and non-fatigue conditions. |
| 6. | Sharawardi et al. (2018) | Implemented the LS-SVM classification technique for the analysis of muscle fatigue using the single-channel EMG data and compared the accuracies with the KNN and ANN algorithms. | This paper indicated the better accuracy of the SVM technique than the KNN and ANN. |

## 2.8 Conclusion

The various methods and their significance for determining neck muscle fatigue were discussed in the whole survey. The problems such as neck pain with

radiculopathy, neck pain without radiculopathy, and spondylosis pain were also described in this section. The review was done based on the modalities used by physiotherapists in the treatment of neck pain.

The various techniques implemented by researches for the classification of EMG data were demonstrated to identify neck muscle fatigue. Moreover, the positive, as well as negative aspects of traction therapy for reduction of neck pain were also established in this section. Based on these conclusions, work regarding the assessment of neck pain has been proposed in the subsequent chapters.