Anastasia Rayes

Neck pain recovery through physical exercises

Bachelor's Degree in Sports and Leisure Management

Sports and Leisure Management

Spring 2024

KAMK • University of Applied Sciences

Abstract

Author: Rayes Anastasia

Title of the Publication: Neck pain recovery through physical exercises

Degree Title: Bachelor's Degree in Sports and Leisure Management

Keywords: neck pain, degenerative cervical spine disorders, isometric exercises, myofascial releasing, proprioceptive neuromuscular facilitation.

Neck pain is very common; it has a prevalence of 55% amongst adults who suffer from degenerative disorders of the cervical spine causing neck pain. The main cause of those disorders is mechanical compression. Degenerative disorders of the spine begin as early as the age of 20 and are the leading cause of neck pain. A thorough history and examination help to identify the functional restrictions and plan an effective physical exercise recovery program.

Purpose: The aim of this study was to compare which physical exercise program, either isometric exercises with proprioceptive neuromuscular facilitation or myofascial releasing with static stretching, whether by itself or in combination, was more effective and beneficial for the treatment of neck pain. The effectiveness was measured using the Neck Pain and Disability Index Questionnaire (Vernon - Mior), Visual Analogue Scale measurements, AROM, the Cervical Extensor Endurance Test, and the Deep Neck Flexor Endurance Test.

Method: A non-randomized, comparative study, where twenty-one individuals with neck pain were placed into three equally organized groups according to their age, gender, pain level, and functional restrictions (seven participants in each group). Group one performed isometric exercises and proprioceptive neuromuscular facilitation (PNF). Group two performed myofascial releasing (MFR) and static stretching. Group three performed the combination; first MFR with static stretching, followed by isometric exercises and PNF. Participants performed an exercise program lasting two weeks on a daily basis with a total of 14 sessions.

Procedure: To assess pain and disability levels, subjective and objective data was collected prior to the first session and two days after the last exercise session using the following methods: Neck Pain and Disability Index Questionnaire (Vernon - Mior), Visual Analogue Scale measurements, AROM, the Cervical Extensor Endurance Test, and the Deep Neck Flexor Endurance Test. The screening, subjective and objective data collection, and measurements, as well as distribution of the physical exercise program, and its presentation to patients with neck pain was carried out based on Vuokatti Sport Academy and the cabinet of Vuokatti Hieronta. Quantitative analysis was made by the completion of the exercise program.

Results: Although the study consisted of a small group of participants, significant pain reduction and improvement occurred in all three groups. Group 3 showed the most notable improvement in all of the tests. Group 1 showed better performance in the Cervical Extensor Endurance Test and the Deep Neck Flexor Endurance Test, as well as larger increase in AROM in all planes compared to Group 2, which demonstrated positive outcomes in NPDI and VAS.

Conclusion: The results conclude that the complex of PNF with isometric exercises is effective in promoting strength and flexibility, which contribute to an increased ROM in the cervical spine and strengthening of the deep neck muscles. While MFR with static stretching is effective in decreasing pain and releasing tension in the fascia, contributing to pain relief and improved postural imbalances related to neck disabilities. However, the most effective showed to be the combination of the two exercise program protocols.

Table of Contents

List of Symbols

CS	Cervical spine
DCSD	Degenerative cervical spine disorders
IE	Isometric exercises
MFR	Myofascial release
PNF	Proprioceptive neuromuscular facilitation
DCM	Degenerative cervical myelopathy
ALL	Anterior longitudinal ligament
PLL	Posterior longitudinal ligament
IVD	Intervertebral disc
OPLL	Ossification of the posterior longitudinal ligament
RA	Rheumatoid arthritis
ACDF	Anterior cervical discectomy and fusion
ROM	Range of motion
AROM	Active range of motion
CEET	Cervical extensor endurance test
MF	Multifidus
PVM	Paravertebral muscle
RCT	Randomized controlled trial
NDI	Neck disability index
VAS	Visual analogue scale

1 Introduction

Degenerative disorders of the cervical spine are a prevalent issue affecting 55% of adults and causing neck pain. This condition is more common in men than women and typically arises mainly after the age of 40. The likelihood of developing degenerative disorders of the spine increases with age and can lead to functional disability in older adults. Early onset of these disorders can occur as early as age 20 and are often related to prior trauma, excessive strain on the spinal cord from certain occupations or sports and abnormal movements. In all cases, a reduction in the size of the cervical canal, particularly in the sagittal plane, is observed. The primary cause of degenerative cervical spine disorders (DCSD) is mechanical compression. (Nuty et al., 2013, p. 2-4)

Treatment and recovery of this group of patients is mainly done by the method of physical exercises. The relevance of this work is due to the need of patients with degenerative disorders of the cervical spine to recover using effective methods of physical and myofascial release (MFR) exercises. Therefore, the study of this topic is currently relevant.

1.1 Commissioning party

The commissioning party for my thesis is Vuokatti Sport Academy. It is an active and work-life oriented place of study. Vuokatti Sport Academy is a leading institution, that located in Vuokatti, Finland. The academy offers a variety of vocational programs in sports, massage and coaching, designed to provide students with practical skills for careers in health and fitness industry. Students benefit from expert coaching, world-class facilities, such as sports arenas, fitness centers and rehabilitation clinics, which are integral to their learning experience.

Vuokatti Sport Academy is committed to innovation and research in the field of sports science. It frequently collaborates with various sports organizations, healthcare institutions and academic researchers. On Vuokatti Sport Academy’s official website there is more detailed information about various educational opportunities and programs. (Vuokatti Sport, n.d.)

The objective from the customer’s point of view is to develop a comprehensive program of neck recovery exercises that potentially may serve as an illustrative example and a reference for educational purposes. The conducted research aims to provide valuable information for physical exercise instructors and rehabilitation therapists, enabling them to integrate evidence-based recovery techniques into their practice.

1.2 Purpose and aims

The purpose of the thesis is to examine the efficacy of integrating isometric exercises (IE) with PNF, static stretching, and MFR techniques in the complex physical exercise recovery program for those who experience neck pain. The main focus is to find the most effective approach to lessen pain and enhance functional abilities in individuals with degenerative disorders of the cervical spine.

The object of research is the process of physical exercise recovery of patients with degenerative disorders of the cervical spine (DCSD). The subject of the research is the application of isometric exercises using the mode of muscle contraction in patients with DCSD as well as proprioceptive neuromuscular facilitation (PNF), static stretching and myofascial release (MFR) techniques.

Aims of the thesis:

The commissioning party aims to gain insights into the effectiveness of integrating isometric exercises, PNF, static stretching and MFR techniques in improving neck pain management. By receiving practical recommendations, the party seeks to develop effective physical exercise recovery program that enhance patient outcomes and quality of life. Comprehensive neck recovery exercise program can serve as educational reference, thereby providing valuable insights for physical exercise instructors and rehabilitation therapists. This way they can integrate evidence-based recovery techniques into their practice contributing to improved management of neck pain.

The student gets an opportunity to deepen understanding in effectiveness of different exercise techniques in improving neck functioning. This research helps student to develop proficiency in research methodologies, data analysis and interpretation by investigating the effect of different physical exercise interventions. This research helps in improving critical thinking and problem-solving skills by addressing complex challenges related to enhancing the well-being in individuals with neck related musculoskeletal issues.

Research questions

1. Which physical exercise recovery complex will be more effective and beneficial in the treatment of neck pain: IE with PNF, static stretching and MFR, whether by itself or in combination?

2. What are the differences in the effectiveness of isometric exercises, PNF, static stretching and MFR when used separately or in combination?

3. How do isometric exercises, PNF, static stretching and MFR affect pain and disability levels in patients with neck pain?

4. How do isometric exercises, PNF, static stretching and MFR affect neck muscle strength and endurance in patients with neck pain?

Hypothesis

It is assumed that the use of complex recovery of the cervical spine using isometric exercises, PNF, static stretching and MFR techniques by patients with neck pain in the subacute stage will effectively restore cervical region functionality, relieve pain, and increase the ability of overall performance during daily activities. (Celik et al., 2022, p. 97)

2 Degenerative cervical spine disorders

Degenerative cervical spine disorder (DCSD) is the changes related with spinal wear and tear. It is an overarching term that describes the various age-related and progressive changes of intervertebral discs, ligaments, and vertebrae, which result in spinal cord impairment through static and dynamic injury mechanisms affecting the neck and upper back (Fig. 1). (Seddighi et al., 2019, p. 2; Kaiser et al., 2019, p. 37-39)

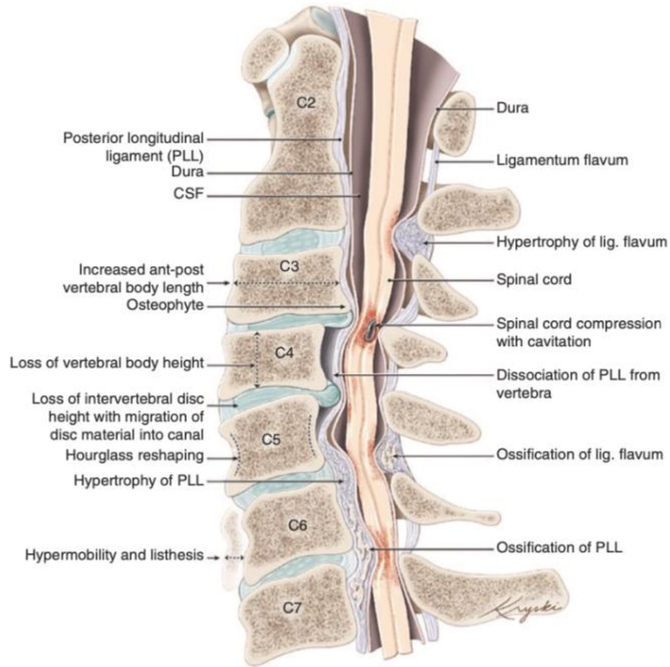

Figure 1. Degenerative changes in patients with DCSD (Kaiser, 2019, p. 38)

2.1 Etiologies

More than 90 % of patients have no identifiable cause for their cervical pain. Symptoms are pain, usually without radiation to the limb, although some patients have radiation into the interscapular area or upper trapezii. Radiation into an arm or forearm generally signifies radiculopathy, particularly when the radicular pain in the extremity exceeds that in the neck. Patients with cervical pain generally have no limb tingling, numbness, or muscle weakness other than weakness associated with pain - producing activities. (Hegmann, 2016, p. 14)

According to Hegmann (2016) the causes of cervical spine disorders are:

- Degenerative cervical spondylosis
- Myelopathy
- Acute disc hernia
- Neoplastic
- Infections
- Trauma
- Cervical spine deformity
- Neurologic injury (ischemic etc..)
- Systemic: OPLL, RA, etc..

Degenerative cervical spondylosis

Cervical spondylosis is a condition where progressive degeneration of the intervertebral discs lead to changes in the surrounding structures. Before, this condition was named osteoarthritis, cervical spondylitis, herniated disc, chondroma, etc., but the term spondylosis is preferable as it is a degenerative as neoplastic or inflammatory condition. (Brain & Wilkinson, 1967, p. 1)

Myelopathy

Degenerative cervical myelopathy DCM is a term that means various age-related changes of intervertebral discs, ligaments and vertebrae, which result in spinal cord damage through static and dynamic injury mechanisms. DCM is the most common cause of nontraumatic spinal cord injury in adults. Symptoms include motor and sensory loss, usually most pronounced in the hands in addition, patients typically present with loss of proprioception and impairment of gait. (Kaiser et al., 2019, p. 37 – 39)

Acute disc hernia

A herniated nucleus pulposus refers to the prolapse of an intervertebral disk through the surrounding annulus fibrosus. This condition is often caused by factors such as age-related degeneration, trauma, or repetitive strain, leading to compression of nearby nerves and resulting in symptoms such as pain, numbness, or weakness in the affected area (Fig. 2). (Harrison, 2023)

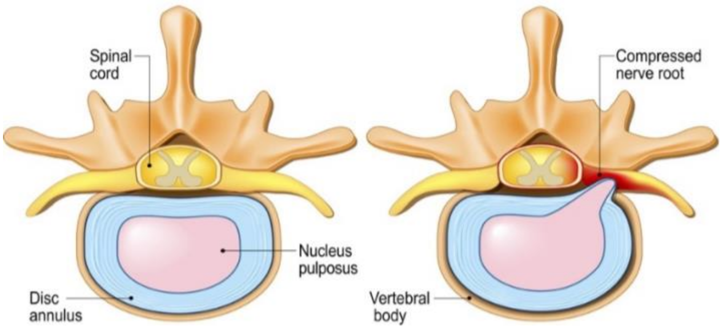

Figure 2. Acute disc hernia. Normal disk (left), herniated disk (right) (Harrison, 2023)

Neoplastic

Condition known as neoplasm, recognized also as tumor, is an abnormal growth of cells that may cause spinal cord compression. It can start from various tissues in the spine including the bones, nerves or surrounding soft tissues. Symptoms of the spinal cord compression caused by neoplasms may include back pain, weakness, numbness, or loss of bowel or bladder control. (Clark, 2005, p. 208)

Infections: epidural abscess

An infection such as epidural abscess is a collection of pus located in the epidural space superficial to the dura mater which surrounds the central nervous system. It can be a result of bacterial infection, trauma or systemic infections such as pneumonia or urinary tract infections. It also may lead to the spinal cord compression. Symptoms may include localized back pain, fever and signs of systemic infection (Fig.3). (Stewart, 2019)

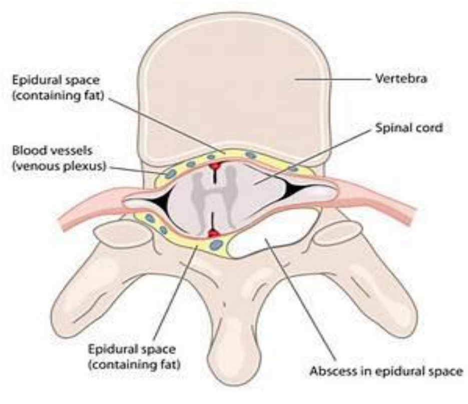

Figure 3. An epidural abscess (Stewart, 2019)

Trauma

Various forms of trauma can lead to chronic instability or a narrowing of the cervical spinal canal. Research has demonstrated that during maximum neck flexion, the posterior wall of the spinal canal elongates by 5 cm, and the anterior wall by 1.5 cm, resulting in stretching of the dura mater and spinal cord. Additionally, movements such as flexion-extension can further reduce the dimensions of the spinal canal, particularly during extension when the yellow ligament bulges. These movements can lead to micro-traumas as compressive elements come into contact (Nuti et al., 2013, p. 4 – 5)

Cervical spine deformity

The Figure 4 illustrates changes in the curvature of the cervical spine. On the left, it shows the normal “lordotic” curvature where the dorsal vertebral body height is less than the ventral height. In the middle, it illustrates the loss of the normal curve due to reduced space between the discs, leading in ventral vertebral body compression. On the right, the figure depicts an extreme form of curvature known as cervical kyphosis, where the neck curve reverses, causing deformation of the intervertebral discs and its further compression.

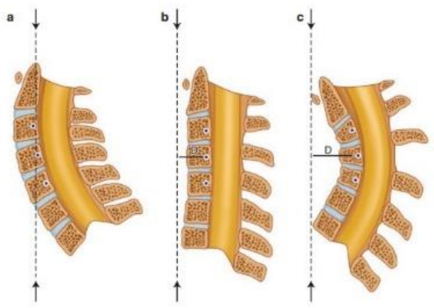

Figure 4. Cervical spine curvature changes (Kaiser, 2019, p. 18)

Neurologic injury

According to Clark (2005, p. 184), in year 1992 were published the International Standards for Neurological and Functional Classification of Spinal Cord Injury. By these standards a complete injury defines as loss of motor function and lack of somatic sensation. Below is the level of injury by the Frankel Classification Grading System:

“Grade A: Complete neurological injury—no motor or sensory function clinically detected below the level of the injury.

Grade B: Preserved sensation only—no motor function clinically detected below the level of injury; sensory function remains below the level of injury but may include only partial function.

Grade C: Preserved motor non-functional—some motor function observed below the level of the injury but is of no practical use to the patient.

Grade D: Preserved motor function—useful motor function below the level of the injury; patient can move lower limbs and walk with or without aid but does not have a normal gait or strength in all motor groups.

Grade E: Normal motor—no clinically detected abnormality in motor or sensory function with normal sphincter function; abnormal reflexes and subjective sensory abnormalities may be present.” (Clark, 2005, p. 189)

Systemic: OPLL, RA

Ossification usually starts behind the body of C5 and progressively spreads through the entire cervical spine. OPLL is a disease that correspond to a specific anatomic type of degenerative cervical spine lesion. Osteogenesis arises from hypertrophied ligament when it "detaches" from the posterior surface of the vertebra by disc protrusions. Cervical rheumatoid arthritis is a chronic inflammatory autoimmune disorder. Mainly, it affects the upper cervical spine (atlanto-axial dislocation) and lesser the lower cervical spine. (Nuti et al., 2013, p. 3-4)

2.2 Clinical presentation of DCSD

DCSD is characterized by motor weakness. Patients with cervical degenerative disease can present with symptoms of nerve root compression, spinal cord compression, axial neck pain, or any combination of the three. The pain is frequently burning in nature. Compression of each nerve root affects a specific portion of the upper extremity (Fig. 5). The C5 nerve root will affect the lateral arm, the C6 nerve root will affect the lateral forearm and hand, the C7 nerve root will affect the middle of the hand and the middle finger, the C8 nerve root will affect the medial hand and forearm, and the T1 root will affect the medial arm. Acute disc herniation causes direct mass effect upon the nerve and causes the onset of an inflammatory cascade. Nerve root compression can result in muscular weakness. (Herkowitz, 2004, p. 123 – 125)

According to Herkowitz (2004) early degeneration of the disc is marked by dehydration of nucleus, in addition to that the disc loses its height. The dehydrated nucleus loses volume as it loses its water content and begins to shrink. The dehydrated disc can no longer perform its bio-mechanical function of dispersing compressive loads, and the loads begin to concentrate between the vertebral body and intervertebral disc where two vertebral bodies become close. This causes abnormal concentration of forces across the articulation and formation of osteophytes as well as protrusion of neuroforamen of the passageway where a spinal nerve root exits the spinal canal.

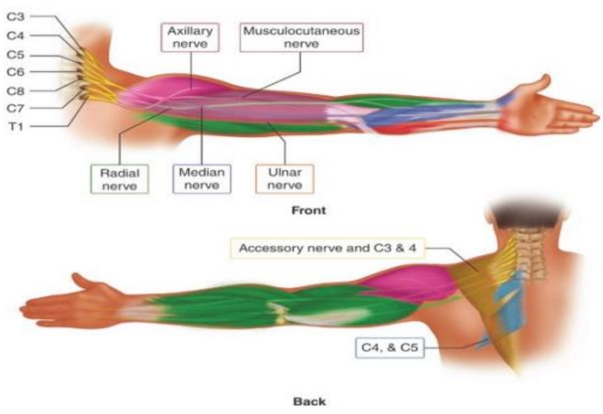

Figure 5. Dermatomal distribution of the cervical nerve roots. (Kaiser, 2019, p. 7)

2.3 Mechanisms of spinal cord compression

A spinal cord compression and tethering of the spinal cord over extrinsic masses in the sagittal plane may play a role in the DCSD process. Both the disc and the ligamentum flavum in the human spine typically occupy similar vertical coordinate levels. When both protrude into the spinal canal at the same level, especially during neck extension, significant spinal cord compression is likely to occur (Fig. 6).

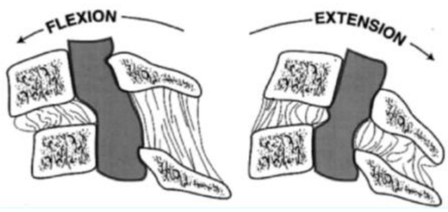

Figure 6. Spinal cord compression during flexion (left) and extension (right) (Rao, 2002, p. 7)

The “straightening” of the spine puts more pressure on the front part of the vertebral bodies. As the normal lordotic curve of the spine gradually diminishes and the kyphosis-producing forces on the spine increase, this process causes the dural sac and spinal cord to bend forward, potentially compressing the nerves and blood vessels (Naderi et al., 1996, p. 3 – 8)

Complex rehabilitation of patients with DCSD

Methods of electronical diagnoses

Various methods are employed for the electronic diagnosis of DCSD. While cervical spine X-rays may lack sufficient details, magnetic resonance imaging (MRI) is often preferred due to its ability to provide detailed images revealing spinal canal constriction and spinal cord compression. Computed tomography (CT) scan help in detecting bony invasions of the canal. The electromyography (EMG) and nerve conduction velocity (NCV) tests help in detecting peripheral nerve problems, such as pinched nerve in neck or arm. The somatosensory evoked potentials (SSEP) test help to stimulate arms or legs, also to examin the brain signals. Any delay in signal transmission time may indicate spinal cord compromise. (Schaffer, 2006, p. 5 – 6)

Medication & pain management

In order to reduce pain, muscle spasms and other symptoms the following DCSD medication may be prescribed, such as analgesics, non-steroidal anti-inflammatory (NSAIDs), muscle relaxants. NSAIDs, as aspirin, ibuprofen etc., provide pain relief, reduce swelling and inflammation. In case of severe pain opioids may be used, although there is a risk of dependence and side effects. Corticosteroids that are taken orally or via injection are with anti-inflammatory affect. Epidural steroid injection that is aoolied directly into the epidural space aims at reducing inflammation and alleviating pain. Also, for treating DCSD antidepressants may be used. Such therapy as trigger point and facet joint injections delivers local anesthetics directly into painful soft tissue or muscles. (Schaffer, 2006, p. 8 – 10).

Nonoperative treatment

Nonoperative treatment aims to alleviate pain and enhance function, even though it does not directly change the narrowing of the spinal canal. However, it may provide long-lasting pain relief and improve overall life function without surgery. A comprehensive rehabilitation program may require three or more months of supervised treatment. Individuals experiencing neck pain often tend to avoid physical activity, which may result in reduced flexibility, strength, and cardiovascular endurance. (Schaffer, 2006, p. 11)

Surgery

If nonoperative treatment failed, then cervical spine surgery is recommended it helps to decompress pressure on nerve and stabilize spine by fusing vertebras together. Anterior cervical discectomy and fusion (ACDF) is often used as a surgical treatment (Fig. 7). Numerous long-term follow-up studies have shown that is effective, in a way of relieving anterior compression on the spinal cord, or decompressing nerve roots.

Figure 7. ACDF with stand-alone anterior cage (Boriani, 2017, p. 75)

Posterior Instrumentation - occipital plate screws can be safely placed in the occiput. After drilling the hole, depth is checked and when penetration of the distal cortex has occurred, they can be tapped bicortically and screws inserted.

Segmental screw fixation (Fig. 8) is achieved using lateral mass (C1 & C3-C6) or pedicle screws (C2 & C7). Fixation can be extended cranially to the skull by occipital plates, and caudally down to the upper-thoracic spine using connectors or double-diameter rods. (Boriani et al., 2017, p. 69 – 80)

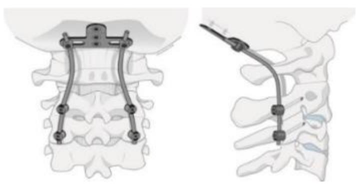

Figure 8. Occipito-cervical (C0–C3) fusion (Boriani, 2017, p. 76)

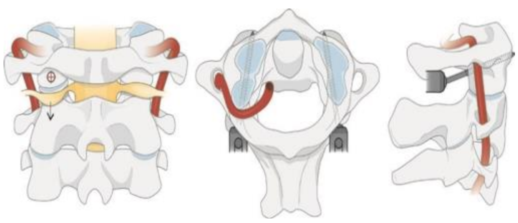

Figure 9**.** C1 lateral mass screws positioning (Boriani, 2017, p. 77)

Posterior surgery is performed through the back of the neck. Two common operations are laminectomy and laminoplasty. These operations are very similar in that they both remove pressure from the spinal cord and spinal nerves. (Schaffer, 2006, p. 15)

3 Physical exercise recovery

Physical exercises are the most used methods for managing spinal disorders. Exercises can help to improve posture, impaired muscle condition, atrophy, muscle endurance, hypomobility or hypermobility, also balance and coordination. Through physical activities muscles start to extract oxygen from the circulating blood more effectively. Physical exercises help to prevent osteoporosis by the increase in the bone density, as well as to reduce pain, restore mobility and functionality. (Cameron & Monroe, 2007, p. 710, p. 713)

The most popular methods of intervention for patients with spinal dysfunction by McKenzie approach is MFR with exercise and education. Exercise is an active treatment which needs the co-operation and assent of the individual to be treated. Exercise prescriptions therefore rely on the participation of the individual and will not be successful if an individual is not compliant with their prescription. The lack of compliance or adherence to exercise programs is one of the greatest reasons for poor results. Individuals often want a “quick fix”, so exercise may not be popular with many patients. It is important that sport instructors explain and educate people about their condition and their exercise program to achieve high levels of adherence. (Wilson et al., 2011, p. 5)

3.1 Cervical screening examination

Cervical screening examination testing should include: Neck pain and Disability index questionnaire (Vernon - Mior); Visual Analogue Scale measurements (VAS); active range-of-motion (AROM) testing, the cervical extensor endurance test (CEET), and the deep neck flexor endurance test. (Olson, 2009, p. 203)

Neck Pain and Disability index questionnaire (Vernon - Mior)

The Neck Pain and Disability Index (NPDI) is a questionnaire that helps to assess neck pain related disabilities by collecting information on how the neck pain affects ability to manage in everyday life. It was developed in 1991 and became one of the most used tools for assessing the neck pain level. The questionnaire consists of ten questions in the following areas: pain intensity; personal care; lifting; reading; headaches; concentration; work; driving; sleeping; and recreation.

Each question consists of six answer choices, scored from 0 to 5 (from no disability up to complete disability). All section scores are calculated and reported on a 0 to 50 scale or from 0 to 100, where 0 is the best possible score and 50 - the worst. (Kaiser et al., 2019, p. 93)

Visual Analogue Scale measurements

Visual analogue scale (VAS) is a scale that measures the intensity of pain. For the first time it was used in 1921 by Hayes and Patterson. The score is determined as: none, mild, moderate, severe on the line between the 0 – "no pain" to 10 – "unbearable pain". (Clark, 2005, p. 280)

Active Range of Motion

To assess active range of motion (AROM) degrees of single-plane movements (flexion, extension, rotation, lateral flexion) a client should perform it individually. This helps to identify tight or restricted muscle groups. If flexion less than 45 to 50 degrees, MFR techniques are directed on releasing the extensors (antagonists). If extension is less than 15 to 25 degrees, the flexors (antagonists) should be released. If lateral flexion is less than 40 to 45 degrees, then lateral flexors (antagonists) are released. If rotation is less than 80 to 90 degrees, rotators on the other side of the neck (antagonists) should be released. (Waslaski, 2012, p. 206-208)

The Cervical Extensor Endurance Test

Weak deep neck extensors can lead to a neck pain, so the aim of the Cervical Extensor Endurance Test (CEET) is to identify the weakness of superficial and deep neck extensors. Patient is in a prone lying position, with the head and neck crossing the edge of the table and the cervicothoracic junction stabilizes. A positive result for muscle weakness of the deep neck extensors is if the chin starts to lengthen incorporated with the neck extension, that indicates the dominance of the superficial neck extensors. Weakness of the deep and superficial extensors of the neck presents if patient is unable to maintain the head in an upright position and starts to flex the neck. (Magee, 2014, p. 182)

The Deep Neck Flexor Endurance Test

The test is useful in assessing the endurance and muscle impairment of the deep neck flexors. This test used in patients with neck pain because there is a relation between the neck pain and limited endurance of the deep neck flexors.

To perform the test, place participant in a supine lying position. When the chin is in the most retracted position, participant should lift the head and neck with about 2.5 cm above the table, keeping the chin tucked in. While counting the time that participant keeps holding the position, place a hand on the table under the head. Ask the participant to tuck the chin and lift the head in case if the head touches hand under. Stop the test if the back of the head touches hand for more than a second. (Magee, 2014, p. 182)

3.2 Proprioceptive Neuromuscular Facilitation

Proprioceptive neuromuscular facilitation (PNF) is a stretching movement that stimulates either the agonist or antagonist muscles right after the start of the stretching. The theory of reciprocal inhibition states that the maximal activation of the muscle inhibits activation of its antagonist, that further leads to its optimal relaxation and stretching. This type of stretching often includes the “hold-relax” technique, where a muscle stretched up to resistance, resists an isometric contraction of a muscle for around 10 seconds, following with the relaxation and further stretching of the muscle. According to the research of the University of Queensland, PNF stretching is the most effective stretching method for increasing range of motion. (Wilson et al., 2011, p. 16)

Hold-relax technique includes passive stretching of the muscle for a few seconds. Further followed by the isometric contraction of the muscle. At this point triggers the reciprocal inhibition reflex 6 to 10 seconds after that isometric contraction becomes possible to stretch muscle deeper. This concept is based on the theory of motor control and motor learning. The emphasis is done on a manual proprioceptive stimulation of muscles and joints, as well as on achieving a balance between muscles-agonists and antagonists. (Wilson et al., 2011, p. 26)

3.3 MFR exercise technique

MFR exercises resemble a form of massage therapy and are often considered a “natural healing” method. The National Center for Complementary and Alternative Medicine (NCCAM) recognizes it as a genuine integrative health treatment, with both immediate and long-term effects on disease, quality of life, and bodily function. Ongoing studies, particularly in China and Europe, have documented various benefits, including relaxation and stress relief, reduction in migraine and tension headaches, improved geriatric activities of daily living, enhanced blood and lymph flow leading to reduced high blood pressure and serum cholesterol levels, pain reduction (including post-surgical pain and elimination of inflammatory processes), muscle strengthening and prevention of postural disorders, faster post-operative recovery, decreased nausea, anxiety and pain associated with cancer treatments, as well as an improvement in perceived quality of life during those treatments.

Furthermore, MFR exercises have shown promise in improving symptoms of type II diabetes, reducing pain in some forms of arthritis, enhancing sleep quality, facilitating rapid recovery from fatigue and muscle soreness in athletes and alleviating insomnia. Additionally, they have been found to be useful in some cases for reducing phantom limb sensations and providing relief for anxiety, depression and post-traumatic stress disorder. (Stone, 2010, p. 111)

According to Waslaski, (2012, p. 203 – 204) asserts that cervical spine restoring begins at the lower back region to be effective on managing clinical neck conditions. Strong myofascial structures of the anterior and posterior torsos should be released to address fascial restrictions effectively on cervical spine muscles. For clients with anterior (forward) shoulder posture, should be first released pectoral and anterior area in order to balance these muscles before starting application on to the cervical spine. It is important to release the restricted areas first, working up the paravertebral muscle group towards the neck to lengthen the spine. By the completion of MFR to continue with stretching to add final release and added space between spinal segments. The overall goal is: to restore normal range of motion; restore muscle lengths; to relieve cervical pain; to stimulate certain rehabilitation processes in damaged fibrose tissues of the spinal disks; to balance muscle groups of the cervical spine; to eliminate organic postural and structural pathology which gives rise to degenerative cervical spine disorders; to restore normal range of motion of the cervical spine; to eliminate myofascial imbalance and restrictions. Also, precautions should be taken into consideration: if during performing MFR person becomes dizzy, nauseous, disoriented, has blurred vision exercises must be discontinued immediately.

3.4 Previous research

3.4.1 Aerobic exercises

There is very little evidence in the literature supporting the use of aerobic exercise in the management of neck pain. For example, in an RCT involving 180 women with chronic neck pain no significant difference was found in the control groups before and after the exercise program. However, other forms of exercise, such as neck strength training and endurance training, have shown promising results in reducing neck pain and disability over a 12-month period. (Slipman et al., 2008, p. 692; Wilson et al., 2011, p. 32)

In an RCT involving patients with acute and chronic neck pain, three groups were compared: Group one received exercise prescribed using the McKenzie method, which aims at 'centralizing' the pain to the back, by moving it away from the arms and legs. The theory of this approach is that the back pain is better tolerated than the pain in arms or legs, making it easier to treat the source than addressing the symptoms. Specific exercises included sitting chin tucks, sitting neck extensions, side bending, rotation, flexion, and shoulder shrugs. Group two received general exercise, and group three received ultrasound therapy. Interestingly, the McKenzie group experienced more rapid improvement in pain intensity during the first three weeks and lower pain scores at six months. However, at the 12-month follow-up, all three groups showed significant improvement with no noticeable difference among them. This study provides further evidence that directional preference exercise, such as those in the McKenzie method, may help patients recover faster. Additionally, it highlights the tendency for most acute neck pain to improve over time, regardless of treatment. (Slipman et al., 2008, p. 688)

3.4.2 Muscle strength and endurance training

Based on recent substantial evidence regarding exercise and neck pain, the prevailing conclusion is that stability dysfunction and functional control should be tackled early with specific low-load exercises. Studies on high-load resistance training have shown promising outcomes: individuals suffering from chronic neck pain can benefit from a six-week neck-strengthening program that incorporates both low and high-load resistance training. Participants who completed this program experienced notable enhancements in pain reduction, disability and isometric neck muscle strength. (Wilson et al., 2011, p. 32)

A comprehensive Finnish study conducted by Ylinen demonstrated that engaging in both strength and endurance training over a 12-month period significantly reduced pain and disability in women suffering from chronic neck pain. In contrast, stretching or aerobic exercise alone showed significantly less effectiveness compared to strength training. Notably, the improvements observed were sustained even during the 3-year follow-up assessments. (Wilson et al., 2011, p. 33).

“Studies by Bronfort et al. (2004), Highland et al. (1992), and Jordan et al. (1998) have suggested that there is a reduction in pain and improvement in function with high load resistance training. Viljanen et al. (2003) found that a programme of dynamic muscle training and relaxation was no better than ordinary activity for women office workers. A combination of isometric exercise, postural correction and use of a neck support pillow has been shown to be effective in the management of chronic neck pain. Isometric exercise in isolation has no effect.” (Wilson et al., 2011, p. 33).

3.4.3 Isometric exercises

An isometric exercise is a type of exercise where muscle contraction occure while maintaining its length and the angle of the joint. The idea of isometric exercises is to apply maximum effort during muscle contraction against the resistance for a period of 6 to 12 seconds. (Cameron & Monroe, 2007, p. 320 – 322)

The research on low load-specific muscle re-education has demonstrated the following findings: isometric function of the cranio-cervical flexors can be improved with deep flexor exercises with a decrease in pain. (Wilson et al., 2011, p. 32)

Spinal stabilization exercises are specifically designed to target the muscles that control segmental stability. The theoretical rationale for spinal stabilization exercises comes from the work of Panjabi, who defines spinal instability as a loss of control or excessive motion in the spinal segment's neutral zone that is related to injury, spinal degenerative changes and muscle weakness. The neutral zone is the portion of movement within the ROM that is not resisted by the passive structures such as the bones and ligaments. Stabilization exercises are specifically designed to target paravertebral muscle group (PVM) in general. (Cameron & Monroe, 2007, p. 718)

An RCT compared the effects of 4 weeks of IE for the PVM with the effect of gradually returning to normal activities and found that both groups' symptoms significantly decreased. The patients had statistically significant reductions in pain and functional disability scores as compared to a control group. These findings persisted at 3-, 6-, and 30-months' follow-up. The authors conclude that training the spinal stabilizing muscles provide dynamic spinal stability while implementing the spinal motion with isometric exercises. (Cameron & Monroe, 2007, p. 726)

Isometric resistance may be given by the sport instructor, gravity or by a constant weight. IE is beneficial when low loading and low levels of balance and control are required. It is also useful in neck pain recovery when range of joint motion is limited or when there is a desire to strengthen a muscle in a particular point in a movement. There is a lack of consensus regarding time of contraction, but 10 seconds is a good minimum starting point. Cervical isometrical exercises are beneficial for cervical muscle spasm, disc arthritis, bulging of a cervical disc, nerve impingement, improve and correct posture and range of motion, cause stress reduction and neck pain. It helps to neutralize muscle imbalance and gain muscle strength. (Wilson et al., 2011, p. 13)

4 Organization and methods of research

4.1 Organization of research

The main purpose of the research was to investigate the effectiveness of various methods of physical exercises in patients experiencing neck pain. The aim was to compare which physical exercise program, either isometric exercises with PNF or MFR and static stretching, whether by itself or in combination was more effective and beneficial in the treatment of neck pain. It was important to find the most effective complex of physical exercises, also, to increase patient's ability to function more efficiently without disability caused by DCSD.

The screening, subjective and objective data collection and measurements, as well as distribution of the physical exercise program, and its presentation to patients with neck pain was carried out on the basis of Vuokatti Sport Academy and the cabinet of Vuokatti hieronta.

It was a non-randomized, comparative study, where quantitative analysis was performed by the completion of the two-week exercise program. The results of the study were interpreted throughstatistical processing of the obtained data to evaluate the effectiveness of each exercise program. By comparing the results across the three groups, this study aimed to determine any differences to find out the most effective approach to managing neck pain. (Wilson et al., 2011, p. 31 – 49).

The objective was to compare three exercise programs, each with a total length of 10 – 15 minutes. Exercise program for the Group 1 consisted of isometric exercises and PNF. For the Group 2 exercise program consisted of MFR and static stretching exercises. For the Group 3 exercise program was a combination of exercise program 1 and 2.

Under observation were twenty-one individuals with neck pain (8 men and 13 women age of 35 to 45 years). They were placed into three somehow equally organized groups according to their age, gender, pain level and functional restrictions. Seven participants in each group: four women and three men in Group 1 and Group 2, five women and two men in Group 3. Group 1 performed isometric exercises and PNF, which supposed to improve muscle strength and flexibility. Group 2 performed MFR and static stretching for reducing tension and promoting relaxation in the muscles. Group 3 performed the combination: first MFR with static stretching, followed by isometric exercises and PNF, to test the hypothesis that a combination of different exercises could be more effective than a single approach.

Participants received an exercise program that was given to them according to their group exercise plan, that they performed for the period of two weeks on daily basis, total of 14 sessions. The measurements and the condition of the patients were assessed twice: before the beginning of exercise program and within 2 days by its completion (see Appendix 1 for exercise program).

The subjective data was collected using the NPDI questionnaire (Vernon - Mior) and by the VAS measurements. The objective data was obtained through AROM testing, the Cervical Extensor Endurance Test, and the Deep Neck Flexor Endurance Test. To assess pain and disability levels, data processing and interpretation of the results of the study was made using quantitative analysis (see Appendix 2 for VAS and The Neck Pain and Disability Index Questionnaire (Vernon - Mior)).

The tasks of physical exercise programs were to reduce the pain, to strengthen weakened and to relax and stretch spastic muscles. To increase active range of motion and to strengthen deep cervical muscles – stabilizers. Also, to increase the space in between intervertebral discs to lessen the compression on the lower spinal segments. Different physical exercise techniques were conducted with patients in the control group aimed at relaxing certain muscles; techniques that improve joint mobility and educate how to actively contract specific muscle groups; how to form a proper coordination in between agonist and antagonist muscles. Physical exercises in isometric mode can create a reliable "muscular corset" of the cervical spine muscle by increasing the muscle strength.

4.2 Complex of physical exercises in the control Group 1

An isometric exercise is a type of exercise where the muscle contracts while maintaining its length and the angle of the joint. Different exercises can be performed both with weights and with own body weight. Isometric exercises target deep muscle layers - stabilizers. These exercises increase not only muscle strength and endurance but also strengthen the tendon tissues and increase their elasticity. The idea of isometric exercises is to apply maximum effort during muscle contraction against resistance for a period of 6 to 12 seconds. In PNF stretching the muscle is stretched up to its resistance level, then it resists to an isometric contraction for about 10 seconds, following with the relaxation and further stretching of the muscle.

Both techniques: isometric exercises and PNF stretching may seem alike, but in IE the idea is to strengthen deep muscle layers, slow-twitch muscle fibers - postural muscles, while in PNF stretching the idea is to maximally stretch – activate a muscle to inhibit activation of its antagonist by reciprocal inhibition process. That leads to its greater relaxation, stretching and increased ROM.

The whole exercise program for control group one may be performed in a standing, sitting, or lying position. The program consists of 2 min. warm up (Table 1).

Name	Comment	Instruction
Lateral flexion	15 – 20 sec.	Side to side neck lateral flexion
Half rotation (180°)	15 – 20 sec.	Glide the chin down by the chest line up to the side and then to the other side, slightly reaching back and away – behind the shoulder line
Head turned to the side 90°	5 repetitions to each side	Turn the head to the side 90 degrees, tilt the chin, and reach with the face up towards the ceiling and then down with the chin touching the shoulder then change to the other side by sliding the chin down by the chest line
Lateral flexion	15 – 20 sec.	Side to side neck lateral flexion
Gliding in a position of lateral flexion	5 repetitions on each side	Lower the ear down to the shoulder (in lateral flexion position) and perform gliding forward and backward while keeping the ear close to the shoulder

Table 1. The warm-up program.

Then followed by the complex of exercises of isometric muscle contraction (Table 2) against the resistance in extension, flexion, side rotation and lateral flexion for 8 – 10 seconds, with a 3 times repetition in the same direction. With a 3 – 5 sec. rest break in between the repetitions. Muscle effort about 60% – 80% of the maximal.

	Instruction
1	The cervical spine is in a neutral position. Facing straight forward, grasp your fingers and place your hands on the back of the head (on occipital bone). Press hands against the head. Push the head backward, slightly increasing the extension (backward flexion), this motion is almost invisible.
2	Same starting position. Grasp your fingers and place hands on the forehead. Press your head against the hands, pushing the head forward and slightly downward in flexion, almost invisible in motion.
3	Turn your head 90° to the left (side rotation). Place both palms on the right cheek. Press and push your face against the palms without visible movement. Repeat the same movement to the right.
4	The cervical spine is in a neutral position. Facing straight forward. Place palm of the hand on the side of the head and press against it, with the ear down towards the shoulder (lateral flexion). The movement is almost invisible. Repeat the same movement to the other side.

Table 2. The complex of Isometric Exercises.

By the completion of IE continue with PNF stretching. It is important to feel yourself and stay in a comfortable range of effort of about 40% – 60% of the max. Find an optimal level of stretch, so that it does not cause any discomfort. The exercises are performed in the following positions: extension, flexion, side rotation, and lateral flexion. Keep each stretch for 8 – 10 sec.

1. Passively stretch the neck muscles by assisting with the weight of your own hands.
2. Then push your head against the hands and maintain the pressure.
3. After that, perform the passive stretch again but increase the ROM.
4. Repeat the second step again (push your head against the hands).

To summarize: PNF stretching is performed in 2 different ranges of motion, first perform a naturally comfortable stretch, then press against the resistance, and then add a deeper and stronger passive stretch (by increasing the ROM by about 15 degrees). Remember to maintain comfortable breathing.

4.3 Complex of physical exercises in the control Group 2

Myofascial Release is an exercising technique that works with both, muscles and fascia. It is a way to stretch myofascial layers mainly with the help of massaging rolls or MFR balls. MFR is very effective as it hydrates the muscles by increased stimulation of blood circulation that helps to decrease compressed myofascial tissues. Simple MFR exercises help to reduce pain, regain healthy movement between the myo- and fascia. MFR helps with different conditions that related with excessive tension of tissues or blood vessels and nerve compression.

While performing self-myofascial release, some of the following things must be considered: it is better to avoid bones, as the main idea of these exercises to release tension out of soft tissues. It is forbidden to perform MFR exercises in case of injury, during the first days, while there is inflammation or swelling. If during performing exercise participant experience acute pain, then tennis ball must be placed in a nearby area, where it doesn't hurt strong. As MFR is a soft tissue restoring technique. So, in any situation where the participant starts to experience sharp pain, tingling, numbness, or shooting - the position of the ball should be changed.

The program consists of warm up, that is the same as in complex of physical exercises in the control Group 1. After warm-up follows complex of MFR exercises with a tennis ball (Table 3). The whole exercise program for the Group 2 should be performed in a supine lying position. Perform each exercise for about 30 – 40 sec. By the completion of all the three exercises change the ball to another side. After working out on both sides move lower to the next position. If more intensity is needed, then buttock should be lifted all the time.

Name	Comment	Instruction
1. Bottom of the scull	- Lift the head and place palm with the ball under the head - at the bottom of the skull. - The ball should be placed in the center, right above the spinal cord. - 10 sec. on each position. - Total of 2 sets.	1. Place the ball in your right palm. Allow your head to lie heavy on the palm with the ball. Support with the other hand to hold the right hand from its outer side. Start to move your head from right to left (as if you were saying "no") at the same time pressing your head against the ball (about 10 sec.) until you feel a burning sensation. 2. Then slightly turn head to the right (for about 10° – 15°) and shake your head in a "no" way. And once again turn for about 10° more to the right and shake there. 3. Then put the ball into the other hand and repeat the same on the left side.

2. Sides of the neck	- The ball is placed into palm under the neck in its mid-section (approximately in C3 – C4 area) - 15 sec. on each position. - Total of 2 sets	1. Place the ball in your right palm in about 1 cm. to the right of the spinal cord. Turn your head to the right (about 20° – 30°). The left hand holds the outer side of the right hand. 2. With a little less intensity and ROM than in the 1st exercise, start moving your head right and left (in a "no" motion). Then change the ball into the other hand and repeat the same on the left side.
3. Top of the shoulder blade	- In each of these 3 positions the ball is placed in between of the shoulder blade and the spinal cord. - Each of the exercises is performed for about 30 – 40 sec. - By the completion of all the three exercises move the ball to the other side. - Only change positions once you have done both sides.	If the ball is on the right side, then the right arm performs the exercises (and opposite). 1. Place your arm up above your head and stretch it away then bring it down to the side of your body. 2. With your arm above the head, stretch it away, and start moving it in a small ROM circle. 3. Then slightly lift buttock off the floor and perform with the arm full ROM circle. If more intensity is needed, then the buttock should be lifted all the time.
4. In the middle of the shoulder blade		
5. Lower edge of the shoulder blade		

Table 3. The complex of MFR exercises with a tennis ball.

By the completion of MFR continue with static stretching (Table 4), it helps further to relax and increase flexibility in muscles that have been worked out with the MFR. While stretching, maintain a comfortable muscle lengthening and avoid the use of excessive force. Each stretch is carried out at a comfortable pace. Hold each static stretch for about 20 – 30 sec. All the exercises are performed in a sitting position. It is crucial to be aware of force level and to stay in a comfortable range, by applying a force of 40% to 60% of maximal effort.

Name	Instruction
Neck Flexion	Lower your chin down towards the chest. Place both hands on the back of your head and gently press the head into a deeper stretch.
Neck Flexion Diagonally	Lower your chin down towards the chest about 30% diagonally to the right and gently press your head downwards with your hands. And then repeat it to the left.
Neck Extension	Tilt your head backwards with the chin leading up towards the ceiling and away from your neck.

Neck Extension Diagonally	Tilt your chin up towards the ceiling and turn your head about 30% diagonally to the right. Gently pull the chin away from your neck. And then repeat it to the left.
Neck Lateral Flexion	Lower your head to the right with your ear towards the shoulder. Place your right palm on the opposite side of your head and gently press it down. Repeat to the left.
Neck Rotation	Slowly turn your head to the right, trying to bring the chin a little behind the right shoulder. Then repeat it to the left.

Table 4. The complex of Static Stretching Exercises.

4.4 Complex of physical exercises in the control Group 3.

The exercise program for the Group 3 starts with the same warm-up as in complex of physical exercises in the control Group 1. Performed in a sequence as follows:

1. Warm up
2. Complex of MFR exercises
3. Static stretching
4. Isometric exercises
5. PNF

The full complex of exercise program is given in Appendix 1.

4.5 Research method

Implementation of Research:

The study is an intervention study aimed at evaluating the effectiveness of different exercise programs for treating neck pain, based on existing theories of exercise and pain management. It was conducted in collaboration with the Vuokatti Sport Academy and the cabinet of Vuokatti hieronta, and involved recruiting 21 individuals with neck pain, who were allocated into three groups. Each group consisted of seven participants: four women and three men in groups 1 and 2 and five women and two men in group 3. This sample size was considered sufficient for the study's scope.

Participants, all within the age range of 35 to 45 years, were evenly distributed among the groups according to their age, gender, pain level and functional restrictions to ensure the groups were as homogeneous as possible. This was determined after the initial test assessment by subjective methods such as the NPDI questionnaire and VAS measurements. Informed consent was obtained from each participant before their involvement in the study.

Participants engaged in an exercise program lasting two weeks, consisting a total of 14 sessions. The exercises were specific to each group, as outlined in the study plan. After the initial tests were conducted each participant was assigned a unique numerical code ranging from 1 to 21. After grouping, a new coding system was implemented for anonymity and simplicity. Participants were coded as G1.1 - G1.7, G2.1 - G2.7 and G3.1 - G3.7, according to their group number and the number of participants. All data was securely stored to ensure confidentiality.

Data collection involved conducting measurements both before the start of the exercise program and within two days after its completion. This allowed comprehensively evaluate the effects of exercise interventions. Subjective data was collected through the following methods: NPDI questionnaire (Vernon - Mior) and VAS. Participants filled in NPDI questionnaire to assess their neck pain and its impact on their daily lives, and rated their neck pain levels on a VAS scale to measure the pain severity (see Appendix 2 for VAS and The Neck Pain and Disability Index Questionnaire (Vernon - Mior)). While the objective measurements included AROM testing, the Cervical Extensor Endurance Test, and the Deep Neck Flexor Endurance Test. The results were processed and interpreted using quantitative analysis to evaluate the effectiveness of each exercise program.

Neck Pain and Disability Index (NPDI):

Equipment needed:

- NPDI questionnaire form; a pen.

Procedure:

To explain the test to the participants, that it is used to assess the severity of the neck pain. To provide with an NPDI questionnaire. Ask the participants to read each question and to mark the appropriate score (see Appendix 2 for The Neck Pain and Disability Index Questionnaire (Vernon - Mior) form).

The original report provided scoring intervals for interpreting (NPDI), ranging from "no disability" to "complete disability." According to these intervals:

- 0 to 4 indicates "no disability."
- 5 to 14 suggests a "mild" level of disability.
- 15 to 24 represents a "moderate" level of disability.
- 25 to 34 signifies "severe" disability.
- Scores above 34 indicate "complete" disability.

Visual Analogue Scale (VAS):

The Visual Analogue Scale (VAS) is used to measure the participants' pain levels ranging from 1 (No Pain) to 10 (Unbearable Pain) (see Appendix 2 for VAS form).

Equipment needed: VAS assessment form

Procedure:

Show participants the VAS scale, explaining that it is used to measure the current pain level. Give intsructions to rate and mark current neck pain on the VAS scale with 1 representing "No Pain" and 10 representing the "Worst Pain."

Active Range of Motion (AROM) Test:

The AROM test assess the degrees of single-plane movements, including flexion, extension, lateral flexion (both right and left), and rotation (both right and left). These measurements were performed independently by the participants with the aim of detecting any tight muscle groups in their neck. The expected normal AROM ranges for these movements are as follows:

- Flexion: 45 to 50 degrees
- Extension: 15 to 25 degrees
- Lateral Flexion: 40 to 45 degrees
- Rotation: 80 to 90 degrees

Equipment needed:

- Inclinometer for measuring degrees of movement; massaging table; a chair.

Procedure:

To explain the test to the participants and inform that it is used to assess their active range of motion in different movements of the neck. It helps to identify any restricted or tight muscles.

Testing:

Instruct the participant to sit with their back against the chair. Test Flexion: ask the participants to gently lower their chin towards the chest trying to touch it. Measure the degree of flexion. Test Extension: instruct the participants to gently tilt their head backward, looking upward. Measure the degree of extension. Test Lateral Flexion (Right and Left): for right lateral flexion, the participants should gently tilt their head towards the right shoulder. For left lateral flexion, tilt the head towards the left shoulder. Measure the degree of lateral flexion for both sides. Test Rotation (Right and Left): instruct the participant to lie in a supine position on the massaging table. For right rotation, ask the participant to rotate the head to the right as if looking over the right shoulder. For left rotation, rotate the head to the left. Measure the degree of rotation for both sides.

Cervical Extensor Endurance Test:

The CEET is designed to assess the endurance and strength of the cervical extensor muscles.

Equipment needed:

- Massaging table, a stopwatch.

Procedure:

Participants receive instructions about performing an endurance test for neck extensor muscles.

Testing:

The participant is in a prone lying position on the massaging table. The head and neck cross the edge of the table and the cervicothoracic junction is stabilized. Once the participant is in the proper position, the practitioner turns on the stopwatch. Participant should be able to maintain a chin tuck position in a neutral for as long as possible or until the point at which he starts to experience pain or discomfort, or fatigue. As soon as the participant releases the position or experiences discomfort, practitioner stops the stopwatch and records the duration (in seconds) in which the participant was able to maintain the chin-tucked position in neutral. The indicator of the dominance of the superficial neck extensors is if the chin starts to lengthen. The weakness of both: the deep and superficial extensors presents if the patient unable to maintain the head in an upright position and starts to flex the neck.

Deep Neck Flexor Endurance Test:

The Deep Neck Flexor Endurance Test is designed to assess the endurance and strength of the deep neck flexor muscles.

Equipment needed:

- Massaging table, a stopwatch.

Procedure:

Participants receive information and instructions about performing an endurance test for the deep neck flexor muscles.

Testing:

The participant is in a supine lying position on the massaging table. The head and neck are in neutral position with the cervical spine in a natural alignment. The participant should maintain a gentle and controlled head lifting movement with the chin one fist distance away from the chest for as long as possible or until the point at which they start to experience pain, discomfort or fatigue. Once the participant is in a proper position with the head lifted off the table, the stopwatch is turned on. As soon as the participant releases the position or experiences discomfort, the stopwatch is stopped and the duration (in seconds) in which the participant was able to maintain the controlled nodding or head lifting movement is recorded.

Ethical considerations:

The study adhered to the ethical guidelines established by the Handbook of WMA Policies (2013, p. 28 – 34) Helsinki Declaration. Participants were fully informed about the study's purpose, procedure and potential risks. Prior to participation each participant signed an informed consent form demonstrating their voluntary participation. Confidentiality and anonymity of participants were thoroughly maintained throughout the study. All of the data were securely stored in password-protected electronic files accessible only to the researcher. Physical documents containing participant information were kept in locked cabinets in a secure space. Participation was entirely voluntary and participants could choose to withdraw from the research at any time (see Appendix 3 for Informed Consent Form).

5 Results

Neck Pain and Disability Index:

The initial assessment of participants' neck pain and disability levels using the NPDI questionnaire revealed a tendency towards reduced neck pain and severe disability within the study groups. Results before (Table 5): the average for Group 1 – 24.1, Group 2 – 24.0, Group 3 – 24.4.

Group	Participants							Total	Average
	1	2	3	4	5	6	7	Total	Average
1	20	23	24	24	25	26	27	169	24,1
2	21	23	24	24	24	26	26	168	24,0
3	19	24	24	25	26	26	27	171	24,4

Table 5. NPDI Test Results - Before.

These scores indicated "moderate" disability (15 - 24) as per the NPDI scoring system. However, it is crucial to emphasise that the calculated average for these groups is less than 25, which indicates a positive shift towards reduced disability levels.

Results after (Table 6): the average for Group 1 – 17,9, Group 2 – 16,6, Group 3 – 13,9.

Group	Participants							Total	Average
	1	2	3	4	5	6	7	Total	Average
1	15	17	17	22	18	18	18	125	17,9
2	14	16	13	18	18	18	19	116	16,6
3	12	11	13	14	14	16	17	97	13,9

Table 6. NPDI Test Results - After.

These scores indicated "moderate" disability (15 - 24) as per the NPDI scoring system for Group 1 and Group 2. While Group 3 demonstrated “mild” disability range (5 - 14) with an average of 13,9. In examining the impact of different exercise programs on neck pain and disability, different tendencies became evident among the three groups:

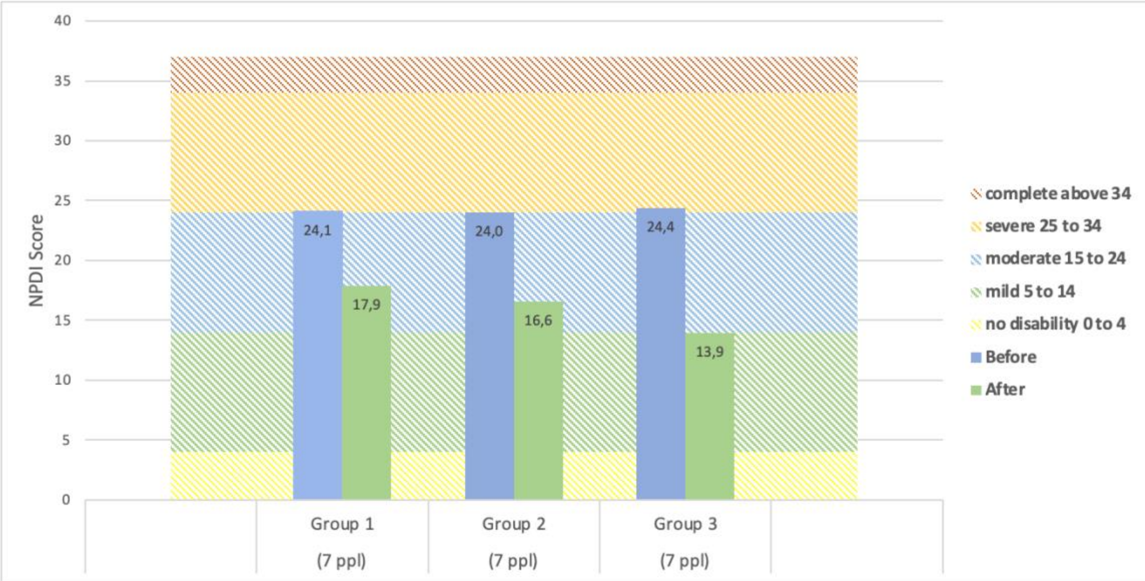

Figure 10. NPDI Test Results Comparison - Before and After Intervention.

Before experiment, participants in Group 1, who performed PNF with Isometric Exercises, presented with a moderate level of neck pain and disability (average NPDI: 24,1). Following the 14-day PNF and isometric exercises program, a significant improvement was observed, with the average NPDI decreasing to 17,9 indicating a reduction to a mild level of disability.

Participants in Group 2, who performed MFR with Static Exercises similar to Group 1 started with a moderate level of neck pain and disability (average NPDI: 24,0). After the 14-day MFR and static exercises program, an improvement was observed, with the average NPDI decreasing to 16,6, indicating a reduction to a mild level of disability.

Group 3, who performed the combination of PNF, isometric, MFR, and static exercises demonstrated the most impactful results in reducing neck pain and enhancing functionality.

Visual Analogue Scale (VAS):

Results before (Table 7): the average for Group 1 – 6,1, Group 2 – 5,7, Group 3 – 6,6.

Group	**Participants**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**Average**
1	5	6	6	5	6	7	8	43	6,1
2	5	6	5	5	5	7	7	40	5,7
3	6	5	6	6	8	7	8	46	6,6

Table 7. VAS Test Results - Before

Participants in all three groups reported moderate pain levels, suggesting a similar level of pain intensity before the initiation of the exercise program.

Results after (Table 8): the average for Group 1 – 4,1, Group 2 – 3,1, Group 3 – 2,3.

Group	**Participants**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**Average**
1	4	3	4	3	5	5	5	29	4,1
2	3	4	3	2	3	4	3	22	3,1
3	1	2	3	2	3	2	3	16	2,3

Table 8. VAS Test Results - After.

Group 1, with an average coefficient of 4,1, revealed a level of pain corresponding to moderate discomfort. In Group 2, the average coefficient was 3,1, indicating a mild level of pain. Group 3 exhibited the lowest average coefficient of 2,3 showing a minimal level of discomfort. In assessing pain level with the Visual Analogue Scale (VAS) ranging from 1 (No Pain) to 10 (Unbearable Pain) the following results were obtained:

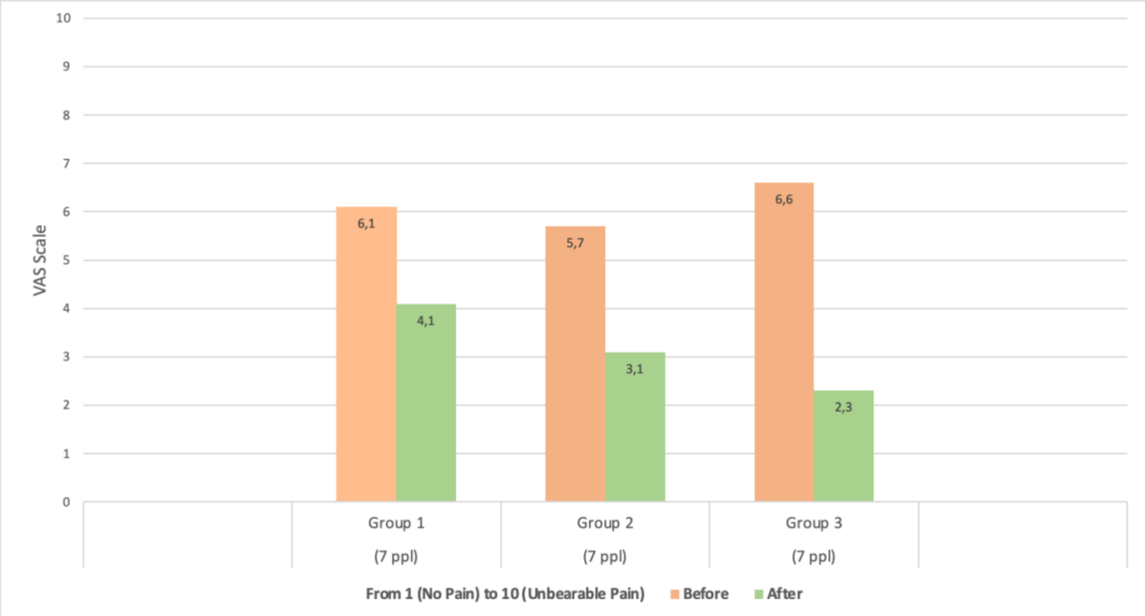

Figure 11. VAS Test Results Comparison - Before and After Intervention.

Participants in Group 1 reported moderate pain level during the initial assessment (average VAS: 6,1). An improvement was observed, with the average VAS decreasing to 4,1. This reflects a notable reduction in pain level, indicating a positive response to the 14-day PNF and isometric exercises program.

Participants in Group 2 started with slightly lower average pain level during the initial VAS assessment compared to Group 1. From average VAS: 5,7 decreasing to 3,1. This reflects a considerable reduction in pain levels, highlighting the effectiveness of the 14-day MFR and static exercises.

Group 3 reported slightly higher average pain level during the initial assessment. Beginning with an initial average VAS score of 6,6 and decreasing to 2,3 after the intervention. This significant improvement, reflecting a transition from moderate to lower level of pain, emphasizes the effectiveness of the combined approach involving PNF, isometric, MFR, and static exercises in relieving pain.

Active Range of Motion Test:

	Flexion (°)	**Extension** (°)	**Lateral Flexion right** (°)	**Lateral Flexion left** (°)	**Rotation Right** (°)	**Rotation Left** (°)
Group 1 (7 ppl)	31,0	14,6	35,6	32,9	69,0	64,3
Group 2 (7 ppl)	38,7	15,6	38,0	37,0	73,7	72,2
Group 3 (7 ppl)	29,9	14,1	34,9	34,0	71,0	68,4

Table 9. AROM Results - Before. Average in degrees.

Based on the AROM test results, it is evident that all three groups exhibited some degree of restriction in their neck movements. The flexion and extension measurements in all groups fell slightly below the expected normal ranges. Even though extension motion for Group 2 falls within the normal range, it is on its lower end. Lateral flexion and rotational movements also displayed minor limitations. Additionally, there was a tendency towards reduced range of motion to the left compared to the right in all groups, indicating a potential asymmetry in cervical mobility.

	Flexion (°)	**Extension** (°)	**Lateral Flexion right** (°)	**Lateral Flexion left** (°)	**Rotation Right** (°)	**Rotation Left** (°)
Group 1 (7 ppl)	42,9	18,1	42,9	41,3	76,9	75,6
Group 2 (7 ppl)	41,1	17,4	41,6	41,1	76,6	76,4
Group 3 (7 ppl)	45,0	20,1	44,4	44,1	81,6	81,3

Table 10. AROM Results - After. Average in degrees.

The post-intervention AROM test results indicate minor restrictions in neck movements across all groups, with some parameters falling slightly below the expected normal ranges. Also Group 1 and Group 2 exhibit normal extension motion as well as Group 3 that showed flexion and extension movements within the normal range. Even though, these findings display a positive neck mobility result, however, they tend to approach the lower limits of the normal range.

The AROM test assess the degrees of single-plane movements, including flexion, extension, lateral flexion (both right and left), and rotation (both right and left).

Flexion:

Figure 12. AROM – Flexion Test Results Comparison - Before and After Intervention

A notable improvement was observed for Group 1, with the flexion range increasing from 31,0 to 42,9 degrees. This suggests positive impact of the exercise program on flexion mobility.

Although the increase in flexion was less compared to Group 1, Group 2 showed an improvement from 38,7 to 41,1 degrees.

Group 3 had the lowest initial flexion range at 29,9 degrees and demonstrated significant enhancement, achieving a flexion range of 45,0 degrees, better than both other groups. Importantly, Group 3 is the only group that reached the normal range of motion, highlighting the effectiveness of the combined exercise approach in restoring flexibility level.

Extension:

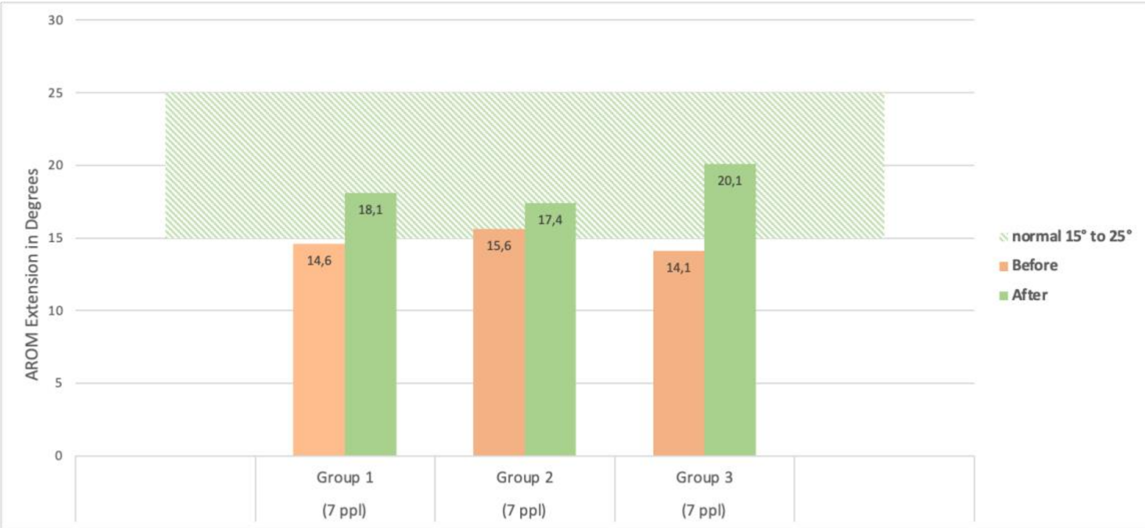

Figure 13. AROM – Extension Test Results Comparison - Before and After Intervention

An improvement was observed in Group 1, with the extension range increasing from 14,6 to 18,1 degrees. This indicates positive progress in extension mobility. The achieved extension range of 18,1 degrees falls within the expected normal range of 15 to 25 degrees, demonstrating not only improvement but also restoration to a normal level of extension.

Despite having slightly higher initial range of 15,6 degrees, Group 2 showed an improvement to 17,4 degrees. However, this improvement is much lesser than the result showed by Group 1, confirming that PNF and isometric exercises are more beneficial for increasing flexibility rather than MFR and static stretching exercises. The final extension range of 17,4 degrees is still within the expected normal range but falls towards the lower end.

Group 3 had the lowest initial extension range of 14,1 degrees before the experiment. After the intervention, it demonstrated significant enhancement to 20,1 degrees that falls in expected normal range and shows substantial improvement in extension mobility.

Lateral flexion right and left:

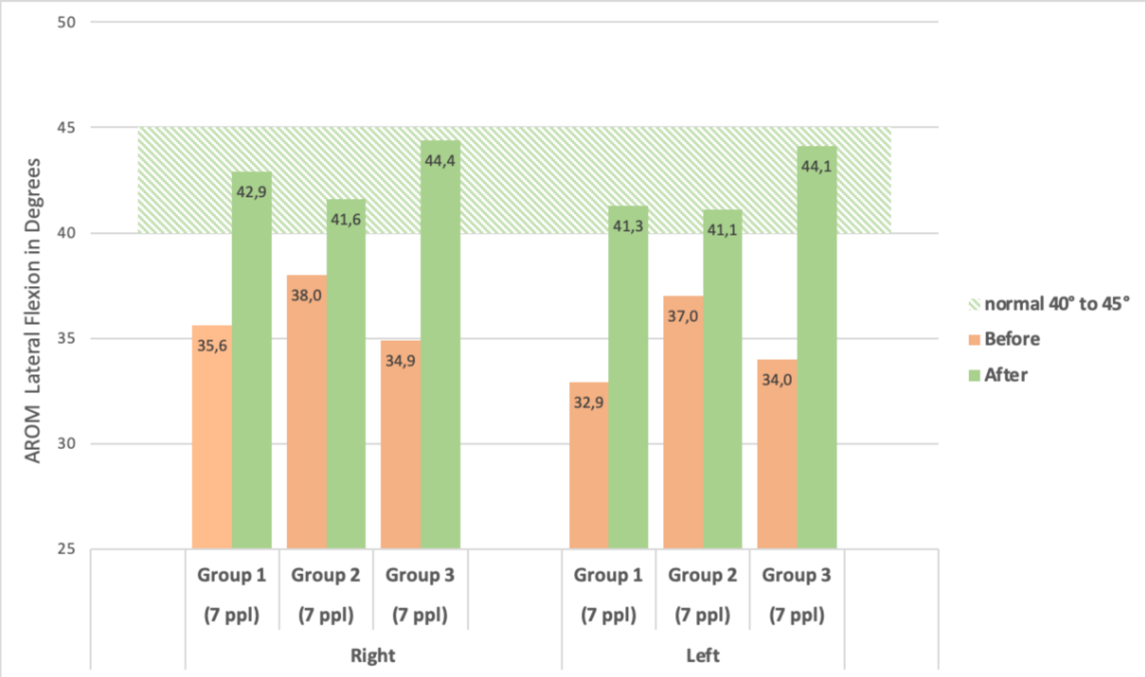

Figure 14. AROM – Lateral Flexion (right and left) Test Results Comparison - Before and After Intervention

Figure 14 shows that all three groups demonstrated an increase in lateral flexion in both directions, reaching normal functioning. Despite starting with the smallest degree of lateral flexion, Group 1 showcased remarkable improvement, almost like Group 3. These results emphasize the efficiency of PNF with isometric exercises in achieving considerable gains in ROM.

In comparison with Group 1, Group 2 started with a higher baseline and demonstrated notable progress. While their improvement in ROM was less than Group 1, the MFR with static exercises contributed to achieving balanced ability for lateral flexion on both sides.

Rotation right and left:

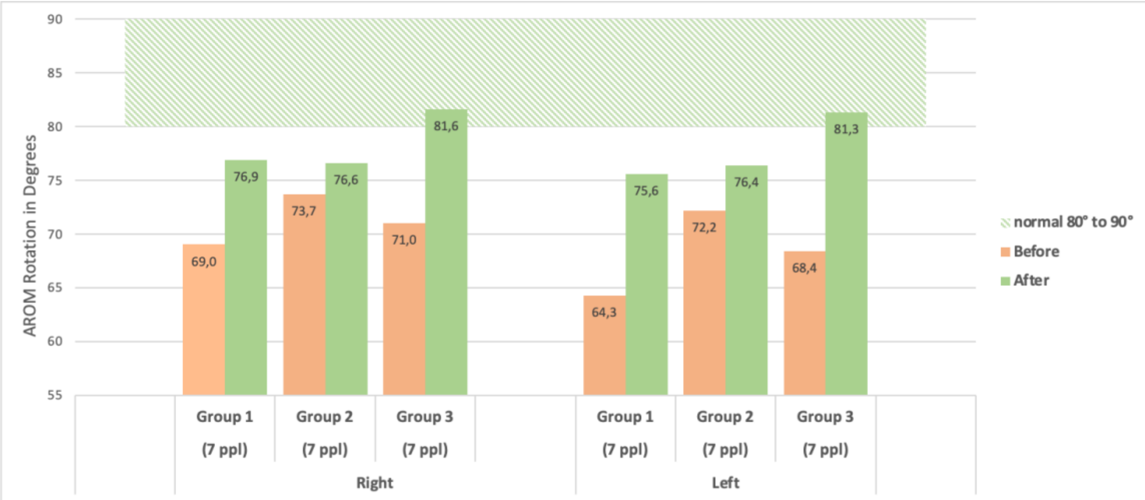

Figure 15. AROM – Rotation (right; left) Test Results Comparison - Before and After Intervention

Figure 15 illustrates the improvements in rotation for each of the group. Group 1 showed notable increase in flexibility, indicating the effectiveness of PNF and isometric exercises in increasing ROM. Comparing Group 1 and Group 2, both exhibited considerable enhancement, emphasizing the efficiency of their exercise programs.

While Group 2 did not reach the normal ROM, it showed balanced improvement in both right and left rotation. This highlights the benefit of MFR and static exercises in promoting muscle relaxation and restoring muscle imbalances.

Group 3 demonstrated outstanding results, achieving a normal range of rotation after the intervention as well as improving muscle imbalance.

Cervical Extensor Endurance Test:

Results before: Group 1 – average endurance time is 54,1 sec.; Group 2 – average endurance time is 61,0 sec.; Group 3 – average endurance time is 48,6 sec. These results indicate that the cervical extensor endurance of the participants in all three groups are relatively close. There is no significant difference between them in this pre-experiment test.

Results after: Group 1 – average endurance time is 72,1 sec.; Group 2 – average endurance time is 71,0 sec.; Group 3 – average endurance time is 73,6 sec. The cervical extensor endurance of participants in all three groups is relatively similar that shows a reasonable level of muscular endurance in the cervical extensor muscles of the participants in this post-experiment test. Group 3 exhibited a slightly higher average than the other two groups.

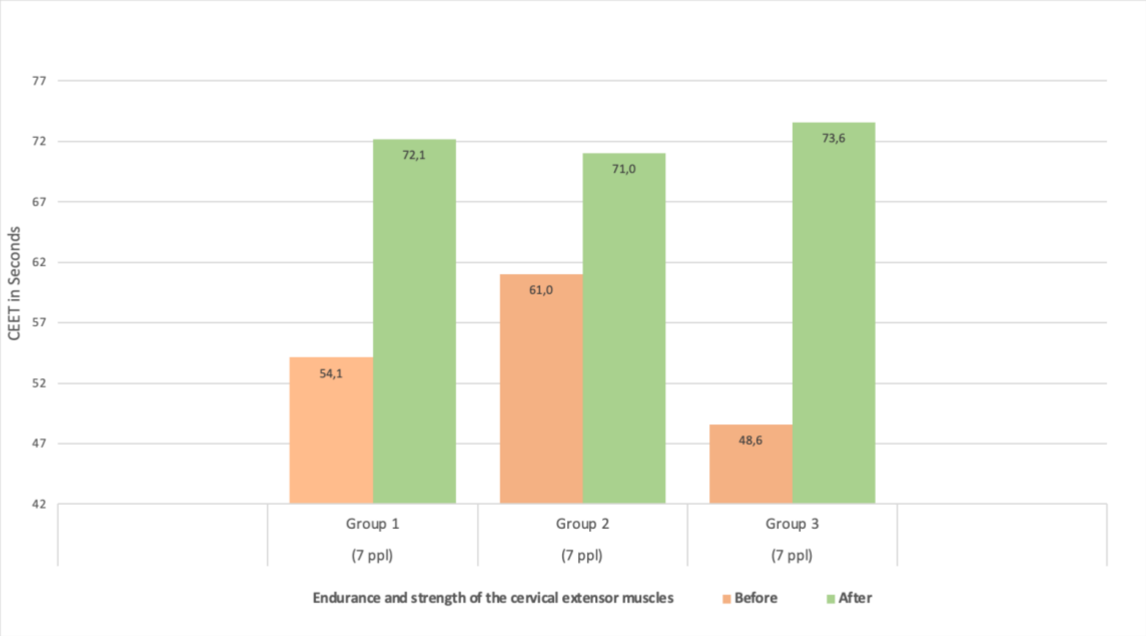

Figure 16. CEET Results Comparison - Before and After Intervention.

Before the experiment Group 1 demonstrated an average cervical extensor endurance time 54,1 sec. Substantial improvement was observed, with the average endurance time increasing to 72,1 sec. signifying a notable enhancement in cervical extensor endurance.

Before the experiment Group 2 exhibited slightly higher baseline endurance compared to Group 1 with an average endurance time 61 sec. Although the increase in endurance time improved to 71 sec. that is less compared to Group 1.

Group 3 began with lower baseline endurance compared to Groups 1 and 2 (average endurance time 48,6 sec). After the experiment Group 3 demonstrated remarkable improvement, with the average endurance time increasing to 73,6 sec.

Deep Neck Flexor Endurance Test:

Results: before: Group 1 – average endurance time is 18,4 sec.; Group 2 – average endurance time is 20,1 sec.; Group 3 – average endurance time is 18,7 sec. These results indicate that the deep neck flexor endurance of the participants in all three groups is relatively close. There is no significant difference between them in this pre-experiment test.

Results after: Group 1 – average endurance time is 27,0 sec.; Group 2 – average endurance time is 26,4 sec.; Group 3 – average endurance time is 29,4 sec. These results indicate that the deep neck flexor endurance of participants in all three groups is relatively close. There is no significant difference between them in this post-experiment test. The Group 3 has a slightly better average endurance in the deep neck flexor muscles, while Group 2 shows a slightly lower average. However, all three groups exhibit reasonable endurance levels, indicating overall good performance in the deep neck flexor endurance test.

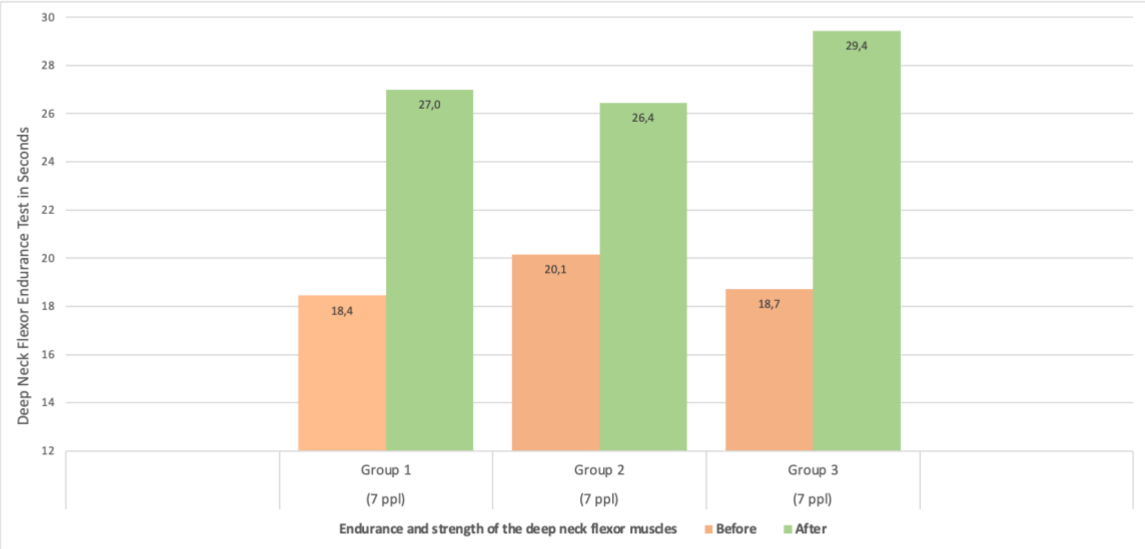

Figure 17. Deep Neck Flexor Endurance Test Results Comparison - Before & After Intervention.

Group 1: PNF with Isometric Exercises

A substantial improvement was observed, with the average endurance time increasing from 18,4 sec. to 27 sec. This indicates significant enhancement in the endurance and strength of deep neck flexors, reflecting positive response to the 14-day PNF and isometric exercises program.

Group 2: MFR with Static Exercises

While the increase in endurance time is notable (before – 20,1 sec. and 26,4 sec. after the intervention), it is less in comparison with the results obtained by the Group 1. This suggests that even though the MFR and static exercises program had positive impact on deep neck flexor endurance is not as effective as PNF and isometric exercises program performed by the Group 1 for strength and endurance of the deep muscles.

Group 3 exhibited remarkable improvement with the average endurance time increasing from 18,7 sec. to 29,4 sec. This emphasizes the positive impact of the combined approach involving PNF, isometric, MFR, and static exercises on deep neck flexor endurance.

All three groups demonstrated positive outcomes, indicating improvements in deep neck flexor endurance after the 14-day exercise programs. Group 2 improved, but to a lesser extent, confirming that PNF in conjunction with IE is more beneficial for enhancing deep muscles' endurance. The most significant enhancement was observed in Group 3. This underscores the effectiveness of the combined exercise approach in enhancing deep neck flexor endurance.

6 Conclusion

Neck Pain and Disability Index (NPDI):

The NPDI test results demonstrate reduction in disability levels across all of the three groups. As NPDI scores showed, before the intervention all groups exhibited moderate level of neck pain and disability. Group 1, performing PNF with isometric exercises started with moderate disability level and demonstrated decrease in NPDI scores after the intervention. Similarly, Group 2, engaged in MFR with static exercises experienced reductions in neck pain and disability. Although starting with slightly lower NPDI scores compared to Group 1, Group 2 showed improvement after the intervention highlighting the effectiveness of MFR and static exercises. Group 3 with its combined exercise program began the experiment with a slightly higher average NPDI score of 24.43 and it demonstrated the most significant improvement dropping with the average NPDI to 13.86 from "severe" to a “mild” disability level. Previous study findings confirm the effectiveness of combining various exercise modalities, such as PNF with isometric exercises and MFR with static exercises in managing neck pain and improving functionality.

Visual Analogue Scale (VAS):

The results of the VAS provide valuable insights into the effectiveness of different exercise programs in managing neck pain. Prior to the intervention participants across all three groups reported moderate level of pain as indicated by their VAS scores. However, following the prescribed 14-day exercise programs, all three groups demonstrated positive shift in pain level, moving from higher initial scores to lower scores after the intervention. Group 1, which engaged in PNF with isometric exercises demonstrated a decrease in average VAS score from 6.14 to 4.14 indicating a positive response to the intervention. Similarly, Group 2, involved in MFR with Static Exercises experienced a considerable reduction in pain levels with average VAS scores decreasing from 5.7 to 3.14. Group 3 demonstrated the most substantial reduction in reported pain level, with average VAS scores decreasing from 6.57 to 2.28 indicating the effectiveness of the combined approach involving PNF, isometric, MFR, and static exercises. These findings support previous research highlighting the benefits of exercise-based approaches in managing neck pain. The observed reductions in pain levels indicate the potential of these interventions to alleviate discomfort and enhance the well-being of individuals suffering from neck pain.

Active Range of Motion (AROM) Test:

Overall, the results of AROM test indicate a positive response to the 14-day exercise interventions in all three groups. Each group demonstrated improvements in flexion, extension, lateral flexion (both right and left), and rotation (both right and left) movements. Group 1 demonstrated significant enhancements in flexion and extension mobility reaching normal ranges. This suggests that the combination of PNF and isometric exercises is effective in promoting muscle strength and flexibility. While not reaching the normal range in all movements, Group 2 demonstrated balanced improvement particularly in lateral flexion and rotation suggesting the benefit of MFR and static exercises in addressing muscle imbalances and relaxation rather than enhancing flexibility. Group 3 displayed the most considerable improvement across all AROM parameters. Particularly, Group 3 achieved normal ranges of motion in flexion, extension, lateral flexion, and rotation, indicating the comprehensive effectiveness of the combined exercise program in restoring neck mobility and addressing muscle imbalances. The results suggest that a combination of different exercise techniques can be highly effective in enhancing neck mobility and reducing restrictions in movement among individuals with neck pain.

Cervical Extensor Endurance Test:

The Cervical Extensor Endurance Test (CEET) results revealed significant improvements in cervical extensor endurance in all three groups before and after the intervention. Group 1 demonstrated enhancement in cervical extensor endurance highlighting the effectiveness of targeted muscle exercises. Group 2 showed less improvement in muscle endurance compared to Group 1 suggesting that MFR with static exercises had a weaker impact on muscle endurance. Group 3, following a combined exercise program showed the most significant enhancement in cervical extensor endurance, indicating the synergistic effect of multiple exercise modalities in improving muscle endurance and strength. These findings underscore the effectiveness of tailored exercise interventions in enhancing muscle endurance among individuals with neck pain. Future research may explore the long-term effects of these exercise interventions and optimise the combinations of exercise modalities to further improvements in cervical extensor endurance and overall neck health.

Deep Neck Flexor Endurance Test:

The results obtained from the Deep Neck Flexor Endurance test demonstrate the impact of different exercise programs on deep neck flexor endurance and provide valuable insights for rehabilitation strategies targeting neck-related conditions. Before the intervention participants in all three groups exhibited relatively similar levels of deep neck flexor endurance indicating a balanced distribution among the study groups. This pre-experiment assessment ensured that the groups were well-matched laying a foundation for meaningful comparisons. Following the 14-day exercise programs significant improvements in deep neck flexor endurance were observed in all three groups. Group 1 demonstrated substantial enhancements in endurance with the average endurance time increasing notably from 18.43 sec. to 27 sec. This highlights the effectiveness of PNF and isometric exercises in strengthening and enhancing the endurance of the deep neck flexor muscles. Group 2 also showed improvement in deep neck flexor endurance post-intervention, but less compared to Group 1. Although the increase in endurance time was less compared to Group 1 indicating that the MFR and static exercises program had a positive impact, but was not as effective as the PNF and isometric exercises program in enhancing deep neck flexor endurance. Group 3 demonstrated remarkable improvements in deep neck flexor endurance. With an average endurance time increasing from 18.71 sec. to 29.43 sec. Group 3 showcased the most significant enhancement among the three groups. This underscores the synergistic effects of combining different exercise modalities to target deep neck flexor muscles effectively. Overall, the findings suggest that tailored exercise interventions focusing on PNF, isometric exercises, and a combination of modalities can effectively enhance deep neck flexor endurance. These results have important implications for rehabilitation programs aimed at improving muscle strength and endurance in individuals with neck-related conditions.

7 Discussion

The study "Neck pain recovery through physical exercises" aimed to compare the effectiveness of different physical exercise programs in easing neck pain, improving functionality and enhancing the range of motion in individuals suffering from degenerative disorders of the cervical spine. The research investigated three groups, each following different exercise programs: Group 1 – PNF with isometric exercises, Group 2 – MFR and static stretching, and Group 3 a combination of both protocols.

The investigation took place at Vuokatti Sport Academy and Vuokatti hieronta, involving 21 individuals thoroughly grouped based on age, gender, pain levels and functional restrictions. The following measurement tools were used for data collection and progress monitoring: NPDI questionnaire (Vernon - Mior); VAS measurements; AROM; the Cervical Extensor Endurance Test; the Deep Neck Flexor Endurance Test. Assessments were conducted both before and after the 14-day exercise programs.

All three groups showed significant progress in all of the tests. However, Group 3 demonstrated the most notable improvement, emphasizing effectiveness of the combined exercise approach in relieving pain, enhancing muscle endurance and increasing ROM. The benefits of each protocol were evident:

Group 1 showed distinct improvement in cervical extensor endurance, deep neck flexor endurance, and AROM, emphasizing the efficacy of PNF with isometric exercises in promoting strength and flexibility, which contributed to an increased range of motion in the cervical spine.

Group 2 demonstrated positive outcomes, especially in NPDI and VAS, serving as evidence that MFR with static stretching is effective in reducing stress and releasing tension in the fascia, contributing to pain relief and improved postural imbalances.

The combination of PNF, isometric exercises, MFR, and static exercises performed by Group 3 demonstrated the most obvious positive effects. It offers comprehensive approach to various aspects of neuromuscular coordination, strength, flexibility, myofascial release and relaxation. Integration of these different exercise programs enhance overall impact on reducing neck pain and disability.

The study validates the limited evidence in the literature regarding the efficacy of aerobic exercises in managing neck pain. Similar to findings reported by Slipman et al. (2008) and Wilson et al. (2011), it was not observed significant improvements in neck pain among participants engaged in aerobic exercise programs. While Slipman et al. (2008) highlighted the benefits of McKenzie method, the current study shows the effectiveness of targeted exercise programs, such as strength training and endurance training. The significant improvements observed in functionality and range of motion among participants in exercise programs for neck pain.

The rapid improvement observed in pain intensity during the initial phase of the study, particularly among participants in Group 1 (PNF with Isometric Exercises), aligns with findings from Slipman et al. (2008) regarding the McKenzie method. However, the sustained benefits observed over 14-day intervention period underscore the potential long-term efficacy of targeted exercise programs. The results of this study will have practical significance for physical exercise instructors and rehabilitation therapists who work with patients suffering from neck pain caused by degenerative disorders of the cervical spine. Specifically, the findings of this research will aid these professionals in recommending effective and targeted exercise recovery programs to their clients.

By investigating the effectiveness of isometric exercises incorporated with PNF, stretching, and MFR techniques in the recovery of patients with neck pain, this study will provide physical exercise instructors and rehabilitation therapists with evidence-based strategies for treating clientss with cervical spine disorders. The results of this study will offer these professionals a deeper understanding of the most effective ways to incorporate these techniques into their clients' exercise program plans.

The study confirms the hypothesis that comprehensive approach effectively reduces neck pain, improves functionality and overall well-being in individuals with degenerative disorders of the cervical spine. The study's findings offer physical exercise instructors and rehabilitation therapists an effective physical exercise program aiding in neck pain recovery, promoting muscle strength and endurance, and restoring flexibility.

Limitations and future research:

In evaluating the reliability of the study's findings, it's essential to acknowledge certain limitation is the small size, which may restrict the applicability of the findings. Additionally, the short duration of the intervention period (14 days) may have limited the extent of improvement that could be observed in participants. Ethical considerations were considered at every point of the study process. Informed consent was taken from all of the participants, outlining the study's objectives, procedures and potential risks. Participants were assured of their right to withdraw from the study at any time. The research adhered to ethical guidelines outlined by relevant professional institutions, ensuring the rights of participants were prioritized throughout the study. In summary, the insights gained from this research serve as valuable guide for effective neck pain recovery approaches.

References

1. Boriani, S., Presutti, L., Gasbarrini, A., Mattioli, F. (2017). *Atlas of Craniocervical Junction and Cervical Spine Surgery.* Springer International Publishing AG.

2. Brain, L., Wilkinson, M. (1967). *Cervical Spondylosis and Other Disorders of the cervical spine.* W.B. Saunders Company.

3. Cameron, M.-H., Monroe, L.-G. (2007). *Physical Rehabilitation. Evidence-Based Examination, Evaluation, and Intervention.* Saunders Elsevier Inc.

4. Clark, C.-R. (2005). *The Cervical Spine. Fourth Edition.* Lippincott Williams & Wilkins.

5. Celik, M.-S., Sonmezer, E., Acar, M. (2022). Effectiveness of proprioceptive neuromuscular facilitation and myofascial release techniques in patients with subacromial impingement syndrome. *Somatosensory & Motor Research. Vol. 39.,* 97 – 105. https://doi.org/10.1080/08990220.2021.2018293

6. Handbook of WMA Policies. Declaration of Helsinki. Ethical Principles for Medical Research involving Human Subjects. D-1964-01-2013 https://www.wma.net/policy/

7. Hegmann, K.-T. (2016). *Cervical And Thoracic Spine Disorders.* American College of Occupational and Environmental Medicine.

8. Herkowitz, H.-N. (2004). *The Cervical Spine Surgery Atlas. Second Edition.* Department of Orthopedic Surgery William Beaumont Hospital.

9. Kaiser, M.-G., Haid, R.-W., Shaffrey, C.-I., Fehlings, M.-G. (2019). Degenerative Cervical Myelopathy and Radiculopathy. Treatment Approaches and Options. *Springer Nature Switzerland AG.* https://doi.org/10.1007/978-3-319-97952-6

10. Magee, D. J. (2014). *Orthopedic Physical Assessment, Ed. 6*. Elsevier Inc.

11. Naderi, S., Benzel, E.-C., Baldwin, N.-G. (1996). *Cervical spondylotic myelopathy - surgical decision making.* Division of Neurosurgery, Marmara & New Mexico University.

12. Nuti, C., Vassal, F., Brunon, J. (2013). *Cervical Myelopathy – Pathology.* Extrait du L'encyclopédie neurochirurgicale.

13. Olson, K.-A. (2009)). *Manual Physical Therapy of the Spine.* Library of Congress Cataloging in Publication Data.

14. Schaffer, J. (2006). *Cervical Stenosis & Myelopathy.* North American Spine Society.

15. Seddighi, A., Hoseini, A.-H., Divanbeygi, A., Alizadeh, S. (2019). Cervical Spine and Degenerative Conditions. Shahid Beheshti University of Medical Sciences Tehran. *Int Clin Neurosci J.* Vol 6, No 1.

16. Slipman, C.-W., Derby, R., Simeone, F., Mayer, T.-G. (2008*). Interventional Spine. An algorithmic approach.* Elsevier Inc.

17. Stone, V.-J. (2010). *The World's best Massage Techniques. The Complete Illustrated Guide.* Fair Winds Press.

18. Waslaski, J. (2012). *Clinical Massage Therapy: A Structural Approach to Pain Management.* Library of Congress Cataloging-in-Publication Data.

19. Wilson, F., Gormley, J., Hussey, J. (2011). *Exercise Therapy in the Management of Musculoskeletal Disorders.* Blackwell Publishing Ltd.

20. Vuokatti Sport. (N.d.). Sport Academy. Retrieved May 28, 2024, from https://vuokattisport.fi/sport-academy/

Figure 1. Kaiser, M.-G., Haid, R.-W., Shaffrey, C.-I., Fehlings, M.-G. (2019). Degenerative Cervical Myelopathy and Radiculopathy. Treatment Approaches and Options. *Springer Nature Switzerland AG.* https://doi.org/10.1007/978-3-319-97952-6

Figure 2. Harrison, D., 2023. *SpineInfo.* Retrieved May 13, 2023, from https://www.spineinfo.com/anatomy/intervertebral-discs-structure-function-and-disorders/

Figure 3. Stewart G..E. (2019), Spinal Infection: Epidural Abscesses Retrieved May 13, 2023, from https://www.healthcentral.com/condition/back-pain/spinal-infection-epidural-abscesses

Figure 18. Dermatomal distribution of the cervical nerve roots. (Kaiser, M.-G., 2019).

Figure 5. Rao R. (2002). Neck Pain, Cervical Radiculopathy, and Cervical Myelopathy: Pathophysiology, Natural History, and Clinical Evaluatio. *The Journal of Bone and Joint Surgery Vol. 84-A.* Num. 10.

Figure 6. Kaiser, M.-G., Haid, R.-W., Shaffrey, C.-I., Fehlings, M.-G. (2019). Degenerative Cervical Myelopathy and Radiculopathy. Treatment Approaches and Options. *Springer Nature Switzerland AG.* https://doi.org/10.1007/978-3-319-97952-6

Figure 7 – 9. Boriani, S., Presutti, L., Gasbarrini, A., Mattioli, F. (2017). *Atlas of Craniocervical Junction and Cervical Spine Surgery.* Springer International Publishing AG.

Apendices

Exercise Program

It is forbidden to perform exercises in case of injury, during the first days, while there is inflammation or swelling. In the case of sharp pain, tingling, numbness, or shooting, the exercise should be stopped.

Warm-up:

Name	Comment	Instruction
Lateral flexion	15 – 20 sec.	Side to side neck lateral flexion
Half rotation (180°)	15 – 20 sec.	Glide the chin down by the chest line up to the side and then to the other side, slightly reaching back and away – behind the shoulder line
Head turned to the side 90°	5 repetitions to each side	Tilt the chin, and reach with the face up towards the ceiling and then down with the chin touching the shoulder then change to the other side by sliding the chin down by the chest line
Lateral flexion	15 – 20 sec.	Side to side neck lateral flexion
Gliding in a position of lateral flexion	5 repetitions on each side	Lower the ear down to the shoulder (in lateral flexion position) and perform gliding forward and backward while keeping the ear close to the shoulder

Complex of MFR Exercises with a tennis ball:

Caution: do not place the ball on the spinal cord. It is better to avoid bones, as the main idea of MFR is to release tension out of soft tissues.

The starting position for all the exercises is in the supine lying position with the knees bent and feet hip width apart.

<table>
<tr><th>Name</th><th>Comment</th><th>Instruction</th></tr>
<tr><td>1. Bottom of the scull</td><td>- Lift the head and place palm with the ball under the head - at the bottom of the skull.
- The ball should be placed in the center, right above the spinal cord.
- 10 sec. on each position.
- Total of 2 sets.</td><td>1. Place the ball in your right palm. Allow your head to lie heavy on the palm with the ball. Support with the other hand to hold the right hand from its outer side. Start to move your head from right to left (as if you were saying “no”) at the same time pressing your head against the ball (about 10 sec.) until you feel a burning sensation.
2. Then slightly turn head to the right (for about 10° – 15°) and shake your head in a “no” way. And once again turn for about 10° more to the right and shake there.
3. Then put the ball into the other hand and repeat the same on the left side.</td></tr>
<tr><td>2. Sides of the neck</td><td>- The ball is placed into palm under the neck in its mid-section (approximately in C3 – C4 area)
- 15 sec. on each position.
- Total of 2 sets</td><td>1. Place the ball in your right palm in about 1 cm. to the right of the spinal cord. Turn your head to the right (about 20° – 30°). The left hand holds the outer side of the right hand.
2. With a little less intensity and ROM than in the 1st exercise, start moving your head right and left (in a “no” motion). Then change the ball into the other hand and repeat the same on the left side.</td></tr>
<tr><td>3. Top of the shoulder blade</td><td rowspan="3">- In each of these 3 positions the ball is placed in between of the shoulder blade and the spinal cord.
- Each of the exercises is performed for about 30 – 40 sec.
- By the completion of all the three exercises move the ball to the other side.
- Only change positions once you have done both sides.</td><td rowspan="3">If the ball is on the right side, then the right arm performs the exercises (and opposite).
1. Place your arm up above your head and stretch it away then bring it down to the side of your body.
2. With your arm above the head, stretch it away, and start moving it in a small ROM circle.
3. Then slightly lift buttock off the floor and perform with the arm full ROM circle.
If more intensity is needed, then the buttock should be lifted all the time.</td></tr>
<tr><td>4. In the middle of the shoulder blade</td></tr>
<tr><td>5. Lower edge of the shoulder blade</td></tr>
</table>

Complex of Static Stretching Exercises:

Each stretch is carried out at a comfortable pace. It is important to be aware of your exertion level and maintain a comfortable range, by applying a force of 40% to 60% of your maximal effort. All the exercises are performed in a sitting position. Hold each static stretch for about 20 – 30 sec.

Name	Instruction
Neck Flexion	Lower your chin down towards the chest. Place both hands on the back of your head and gently press the head into a deeper stretch.
Neck Flexion Diagonally	Lower your chin down towards the chest about 30% diagonally to the right and gently press your head downwards with your hands. And then repeat it to the left.
Neck Extension	Tilt your head backwards with the chin leading up towards the ceiling and away from your neck.
Neck Extension Diagonally	Tilt your chin up towards the ceiling and turn your head about 30% diagonally to the right. Gently pull the chin away from your neck. And then repeat it to the left.
Neck Lateral Flexion	Lower your head to the right with your ear towards the shoulder. Place your right palm on the opposite side of your head and gently press it down. Repeat to the left.
Neck Rotation	Slowly turn your head to the right, trying to bring the chin a little behind the right shoulder. Then repeat it to the left.

Complex of Isometric Exercises:

Perform each exercise for 8 – 10 sec, 3 reps each, with a 3 – 5 sec. rest in between. Muscle effort should be about 60% – 80% of the max. The exercise program can be performed in a standing, sitting, or lying position. Breathing during contraction phase is comfortable and natural.

	Instruction
1	The cervical spine is in a neutral position. Facing straight forward, grasp your fingers and place your hands on the back of the head (on occipital bone). Press hands against the head. Push the head backward, slightly increasing the extension (backward flexion), this motion is almost invisible.
2	Same starting position. Grasp your fingers and place hands on the forehead. Press your head against the hands, pushing the head forward and slightly downward in flexion, almost invisible in motion.
3	Turn your head 90° to the left (side rotation). Place both palms on the right cheek. Press and push your face against the palms without visible movement. Repeat the same movement to the right.
4	The cervical spine is in a neutral position. Facing straight forward. Place palm of the hand on the side of the head and press against it, with the ear down towards the shoulder (lateral flexion). The movement is almost invisible. Repeat the same movement to the other side.

Complex of PNF stretching.

It is important to feel yourself and stay in a comfortable range of effort of about 40% – 60% of the max. Find an optimal level of stretch, so that it does not cause any discomfort. The exercises are performed in the following positions: extension, flexion, side rotation, and lateral flexion. Keep each stretch for 8 – 10 sec.

5. Passively stretch the neck muscles by assisting with the weight of your own hands.
6. Then push your head against the hands and maintain the pressure.
7. After that, perform the passive stretch again but increase the ROM.
8. Repeat the second step again (push your head against the hands).

To summarize: PNF stretching is performed in 2 different ranges of motion, first perform a naturally comfortable stretch, then press against the resistance, and then add a deeper and stronger passive stretch (by increasing the ROM by about 15 degrees). Remember to maintain comfortable breathing.

VAS; The Neck Pain and Disability Index Questionnaire (Vernon - Mior)

0-10 VAS Numeric Pain Distress Scale

No pain — Moderate pain — Unbearable pain

0 1 2 3 4 5 6 7 8 9 10

NECK PAIN AND DISABILITY INDEX (VERNON-MIOR)

PATIENT NAME: ______________________ FILE #__________ DATE:______________

Please read instructions: This questionnaire has been designed to give the doctor information as to how your back pain has affected your ability to manage in everyday life. Please answer every section and mark in each section **only one** box which applies to you. We realize you may consider that two of the statements in any one section relate to you, but just mark the box which most closely describes your problem.

SECTION 1 – PAIN INTENSITY
- I have no pain at the moment
- The pain is mild at the moment
- The pain comes and goes and is moderate
- The pain is moderate and does not vary very much
- The pain is severe but comes and goes
- The pain is severe and does not vary much

SECTION 2 – PERSONAL CARE
- I can look after myself normally without causing extra pain
- I can look after myself normally but it causes extra pain
- It is painful to look after myself and I am slow and careful
- I need some help but manage most of my personal care
- I need help every day in most aspects of self care
- I do not get dressed, I wash with difficulty and stay in bed

SECTION 3 – LIFTING
- I can lift heavy weights without extra pain
- I can lift heavy weights but it gives extra pain
- Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example on a table
- Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned
- I can lift very light weights
- I cannot lift or carry anything at all

SECTION 4 – READING
- I can read as much as I want to with no pain in my neck
- I can read as much as I want to with slight pain in my neck
- I can read as much as I want with moderate pain in my neck
- I can't read as much as I want because of moderate pain in my neck
- I can hardly read at all because of severe pain in my neck
- I cannot read at all

SECTION 5 – HEADACHES
- I have no headaches at all
- I have slight headaches which come infrequently
- I have moderate headaches which come infrequently
- I have moderate headaches which come frequently
- I have severe headaches which come frequently
- I have headaches almost all of the time

SECTION 6 – CONCENTRATION
- I can concentrate fully when I want to with no difficulty
- I can concentrate fully when I want to with slight difficulty
- I have a fair degree of difficulty in concentrating when I want to
- I have a lot of difficulty in concentrating when I want to
- I have a great deal of difficulty concentrating when I want to
- I cannot concentrate at all

SECTION 7 – WORK
- I can do as much work as I want to
- I can only do my usual work, but no more
- I can do most of my usual work, but no more
- I cannot do my usual work
- I can hardly do any work at all
- I can't do any work at all

SECTION 8 – DRIVING
- I can drive my car without any neck pain
- I can drive my car as long as I want with slight pain in my neck
- I can drive my car as long as I want with moderate pain in my neck
- I can't drive my car as long as I want because of moderate pain in my neck
- I can hardly drive at all because of severe pain in my neck
- I can't drive my car at all

SECTION 9 – SLEEPING
- I have no trouble sleeping
- My sleep is slightly disturbed (less than 1 hour sleepless)
- My sleep is mildly disturbed (1-2 hours sleepless)
- My sleep is moderately disturbed (2-3 hours sleepless)
- My sleep is greatly disturbed (3-5 hours sleepless)
- My sleep is completely disturbed (5-7 hours sleepless)

SECTION 10 – RECREATION
- I am able to engage in all my recreation activities with no neck pain at all
- I am able to engage in all my recreation activities, with some pain in my neck
- I am able to engage in most, but not all of my usual recreation activities because of pain in my neck
- I am able to engage in few of my usual recreation activities because of pain in my neck
- I can hardly do any recreation activities because of pain in my neck
- I can't do any recreation activities at all

RATE THE SEVERITY OF YOUR NECK PAIN

NO PAIN ______________________________ **EXTREME PAIN**

1 2 3 4 5 6 7 8 9 10

Informed Consent Form

Researcher: Anastasia Rayes

Title of the Study: Neck Pain Recovery Through Physical Exercises

Study Description: You are invited to participate in a research study investigating the effectiveness of different exercise programs for managing neck pain and improving overall neck function. The study aims to compare the outcomes of three different exercise interventions: isometric exercises with proprioceptive neuromuscular facilitation (PNF), myofascial releasing (MFR) with static stretching, and a combination of both programs. Participation in this study is voluntary.

Procedure: You will be randomly assigned to one of three exercise groups. Each exercise program will last for two weeks with a total of 14 sessions. You will be required to perform exercise program daily for duration of the two-week period. Before and after the exercise program you will undergo assessments including the Neck Pain and Disability Index Questionnaire, Visual Analogue Scale measurements, range of motion tests, and endurance tests for neck muscles.

Risks and Benefits: The exercise programs may cause temporary discomfort or muscle soreness. The potential benefits include reduction in neck pain, improvement in neck function and increased flexibility and strength.

Confidentiality: Your personal information and study data will be kept anonymeus and will only be available to the researcher. Your data will be stored securely and will not be shared with any third parties.

Voluntary Participation: Your involvement in this study is completely voluntary.

Consent: I have read and understood the above information. I voluntarily agree to participate in this research and consent to the procedures outlined above.

Date: ____________________ **Participant Signature:** ________________________