MOHAMMAD ALJALLAD DEPARTMENT OF PHYSIOTHERAPY & REHABILITATION MASTER THESIS ISTANBUL-2019

T.C.
YEDITEPE UNIVERSITY
INSTITUTE OF HEALTH SCIENCES
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THE ACUTE EFFECT OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION ON CERVICAL RANGE OF MOTION, STRENGTH AND PROPRIOCEPTION

MASTER THESIS

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ONAY

Bu tez Yeditepe Üniversitesi Lisansüstü Eğitim-Öğretim ve Sınav Yönetmeliğinin ilgili maddeleri uyarınca yukarıdaki jüri tarafından uygun görülmüş ve Enstitü Yönetim Kurulu'nun 16/07/2019 tarihi ve 2019/12-12 sayılı kararı ile onaylanmıştır.

Prof. Dr. Bayram YILMAZ

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DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

Date

16/07/2019

Signature

Name Surname

Mohammad aljallad

DEDICATION

I would like to dedicate this thesis to my Parents, Majdi Al-Jallad and Majedah AlTaji, and my sister and brothers and to all my friends, whose support made this thesis possible.

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LIST OF SYMBOLS AND ABBREVIATIONS

AROM	Active Range of Motion
AMEDA	Active Movement Extent Discrimination Assessment
BMI	Body Mass Index
CNS	Central Nervous System
CRAC	Contract-Relax-Antagonist-Contract
GTO	Golgi Tendon Organs
JPR	Joint Position Reproduction
MTU	Musculotendinous Unit
PNF	Proprioceptive Neuromuscular Facilitation
ROM	Range Of Motion
sEMG	Surface Electromyography
TTDPM	Threshold to Detection of Passive Motion

ABSTRACT

Jallad, M. (2019). The Acute Effect of Proprioceptive Neuromuscular Facilitation on Cervical Range of Motion, Strength and Proprioception. Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, MSc thesis. Istanbul.

Proprioception is the ability to sense the information raised from the musculoskeletal system regarding the movement and position of body part in space. Proprioceptive neuromuscular facilitation (PNF) is a treatment approach that develops and restores proper functioning of joints and related structure by using neurological reflexes. The aim of this study was to investigate the acute influence of PNF on cervical proprioception, range of motion (ROM) and strength in healthy population, 104 participants were randomly assigned to three groups, 1.PNF stretching, 2. PNF Patterns and 3. Control group. Cervical proprioception and ROM were measured using cervical ROM device while muscle strength measured using a myometer device. Measurements were taken before and after intervention, the intervention was done once, PNF stretching was done using contract-relax-antagonist-contract (CRAC) technique, PNF patterns were performed using Dynamic of reversals technique, the control group received only passive ROM without causing any stretch. The between the groups analysis showed significant difference only in left rotation muscles strength ($p=0.006$) for PNF stretching and PNF pattern over the control group, while the within group analysis showed significant difference for PNF stretching group in extension proprioception and right rotation ROM ($p \leq 0.05$). For PNF patterns group extension, right rotation, right side bending and left side bending proprioception ($p \leq 0.05$), extension and right rotation ROM ($p \leq 0.05$), right and left rotation muscles strength ($p \leq 0.05$).for the control group flexion, extension, right rotation and right side bending proprioception ($p \leq 0.05$), extension, left and right side bending ROM ($p \leq 0.05$). PNF stretching showed the least influence on all outcome measures, while the results of PNF pattern group indicating that it might be a promising technique to influence the outcome measures in this study, however, with current results and the lack of in the literature, a recommendation can not be made for the use of PNF stretching and PNF patterns to influence cervical proprioception, ROM and strength.

Keywords: Cervical spine, Proprioceptive Neuromuscular Facilitation, stretching, Proprioception.

ÖZET

Jallad, M. (2019). Servikal Propriosepsiyonda Propriyoseptif Nöromüsküler Kolayığın Akut Etkisi, Hareket Açıklığı ve Kuvvet. Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon ABD, Master Tezi. İstanbul.

Propriyosepsiyon, kas-iskelet sisteminden toplanan bilgileri algılama yeteneğidir ve vücut bölümünün uzayda hareketini ve konumunu dikkate alır. Propriyoseptif Nöromüsküler Fasilitasyon (PNF), nörolojik refleksleri kullanarak eklemlerin ve ilgili yapılar düzgün işleyişini geliştiren ve eski haline getiren bir tedavi yaklaşımıdır. Bu çalışmanın amacı PNF'nin servikal propriyosepsiyon, hareket açıklığı (ROM) ve sağlıklı popülasyondaki güç üzerindeki akut etkisini araştırmaktadır. 104 katılımcı rastgele üç gruba atandı, 1. PNF germe, 2. PNF paternleri ve 3. Kontrol grubu. Servikal propriyosepsiyon ve ROM servikal ROM cihazıyla ölçüldü, kas gücü ise bir myometer cihazı kullanılarak ölçüldü. Müdahale öncesi ve sonrası ölçümler alındı, müdahale bir kez yapıldı, PNF germe contract-relax-antagonist-contract (CRAC) yöntem ile kullanarak yapıldı, PNF paternleri Dinamik ters teknik kullanılarak yapıldı ve Kontrol grubunda herhangi bir esnemeye yapılmadı sadece pasif ROM uygulandı. Gruplar arasındaki yapılan analizler, kontrol grubu üzerinde PNF germe ve PNF paternleri için yalnızca sol rotasyon kas kuvvetinde ($p = 0.006$) anlamlı farklılık gösterirken, diğer tarafta grup içi analizlerde, ekstansiyon propriyosepsiyonunda ve sağ rotasyon ROM'da, PNF germe grubu için anlamlı farklılık gösterdiler ($p \leq 0.05$). PNF paternleri için grubu ekstansiyon, sağa dönüş, sağa lateral fleksiyon ve sola lateral fleksiyon propriyosepsiyon ($p \leq 0.05$), ekstansiyon ve sağa dönüş ROM ($p \leq 0.05$), sağa ve sola dönüş kas kuvveti ($p \leq 0.05$) ve kontrol grubu için fleksiyon, ekstansiyon, sağa dönme ve sağa lateral fleksiyon propriyosepsiyon ($p \leq 0.05$), ekstansiyon, sol ve sağ lateral fleksiyon ROM ($p \leq 0.05$). PNF germe tüm sonuç ölçütleri üzerinde en az etkiyi gösterdi ve yeni fizyolojik mekanizma önerilmesi gerektiğini gösterdi, diğer tarafta PNF paternleri grubunun sonuçları, bu çalışmada sonuç ölçütlerini etkilemenin ümit verici bir teknik olabileceğini gösterdi, Ancak, güncel sonuçlarla ve literatürdeki eksikliklerle servikal propriyosepsiyon, ROM ve kuvveti etkilemek için PNF germe ve PNF paternler kullanımı için tavsiye edilmez.

Anahtar kelimeler: Servikal, Propriyoseptif Nöromüsküler Kolayığın, germe, Propriosepsiyon

1. INTRODUCTION

The cervical spine is the most mobile region of the spine with ability to move in all plans of motion, this to allow the head to scan more real-estate of the environment, while also providing enough stability to hold the head and house sensitive organs and structures[(1-2)]. this also makes the cervical spine more susceptible to injuries where the prevalence of conditions like neck mechanical pain are high among all populations[3].

Proprioception is the ability to sense the information raised from the musculoskeletal system regarding the movement and position of body parts in space [(4)], there are many types of proprioceptors in the body such as skin, joint capsule and connective tissue but the largest contributors to joint position sense are the intermuscular receptors which are Golgi tendon organs (GTO) and muscle spindles[(5-6)]. In this study we will take interest in two mechanisms of proprioception that supposedly be the underlying mechanisms in which PNF acts to achieve certain goals, these are GTOs and muscle spindles.

Compared to the muscles in the limbs, the cervical region contains high amount of GTOs and muscle spindles, Muscle spindles are arranged in highly structured arrays of paired, parallel configurations specially in the inter transverse and centro-transverse intervertebral[(6-7)].

Proprioceptive neuromuscular facilitation (PNF) is a treatment approach that develops and restores proper functioning of joints and related structure by using neurological reflexes[(8)]. Also, it can be defined As a method of influencing neuromuscular processes by stimulating proprioceptors[(9)]. PNF techniques initially were developed to be used for neurorehabilitation patients by either causing a facilitation effect or inhibition effect, shortly after that, PNF techniques merged to be a treatment approach in conditions other than those with neurological origin[(8-9)].

Since PNF techniques are widely accepted and practiced among therapists, the results of this study could be easily translated into clinical practice, also will give an indication on inhibitory and facilitatory effect of PNF.

The influence of multiple techniques on cervical proprioception, range of motion (ROM) and strength can be found in the literature, to the best of our knowledge there are no studies that investigated PNF to influence these outcome measures. Therefore, the aim of this study was to investigate the acute influence of Proprioceptive neuromuscular facilitation on cervical proprioception, ROM and strength properties.

2. GENERAL INFORMATION AND LITERATURE REVIEW.

2.1 Proprioception

The definition of proprioception in the literature is inconsistent, semantics of proprioception made defining it a hardship that is without counting the broad complex neurophysiological process that construct proprioception, where some researchers have used the same definition of proprioception with different words and thus resulted in confusion in the literature, however , in this context we will use the definition: Proprioception is the ability to sense the information raised from the musculoskeletal system regarding the movement and position of body part in space[10].

Proprioceptive information is processed at multiple levels in the central nervous system, involving high cortical centers, subcortical nuclei, cerebellum, brain stem and at a spinal level. The conscious proprioception information is Conveyed through the ascending pathways to the medulla and the thalamus reaching the somatosensory cortex (figure 1.A). Unconscious proprioception information is transferred by the spinal nucleus to the cerebellum[11] (figure1.B).

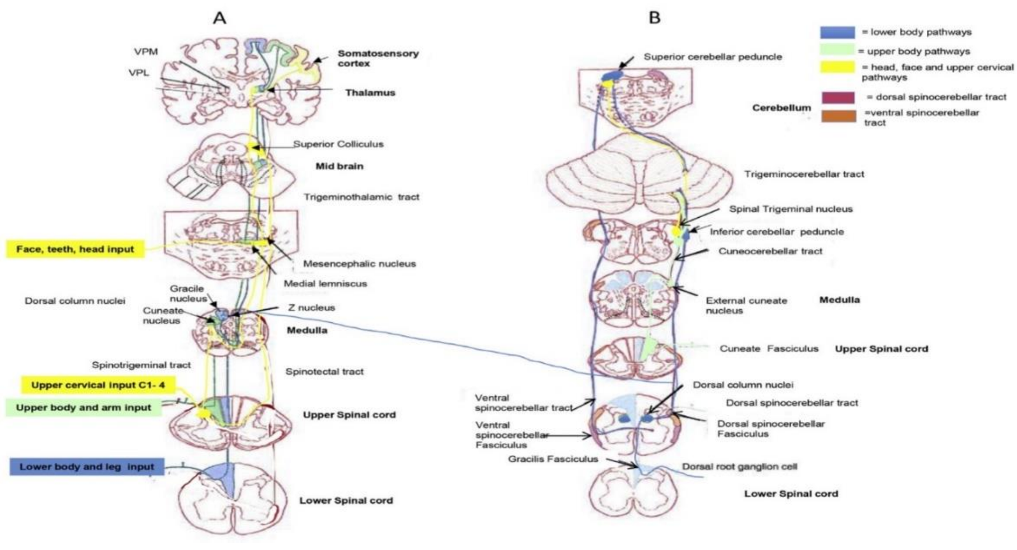

Figure 1 A) Dorsal column Medial lemniscus pathway to Cerebral Cortex for conscious proprioception, B) Spinocerebellar pathway to the Cerebellum for unconscious proprioception[12].

The involvement of cervical proprioceptive information in head and eye movement, control and balance, cervical proprioceptive information is transferred to the superior colliculus in the midbrain[(12)].

Proprioceptive information is conveyed from mechanoreceptors to the central nervous system, this is done by converting the mechanical stimuli to action potential. Mechanoreceptors vary in location and actions according to their type[12].

Table 1 mechanoreceptors of the human body.

Mechanoreceptors	Type	Stimulation
Muscle-tendon unit	Muscle spindle Golgi tendon organ	Muscle length Velocity of change of muscle length Active muscle tension
Joint	Ruffini ending Pacinian ending Mazzoni ending Golgi ending	Low and high load tension and compression loads throughout the entire ROM
Fascia	Ruffini ending Pacinian ending	Low and high tension loads during joint movement
Skin	Hair follicle receptor Ruffini ending Pacinian ending Merkel ending Meissner ending	Superficial tissue deformation/ stretch or compression during joint movement

Muscle spindles are specialized structures that are found within muscles[13], muscle spindles can detect changes of muscle length and since they contain group Ia axons, they can conduct action potentials very rapidly[13].

Muscle spindles contains modified intrafusal fibers where they are innervated by gamma motor neurons that are different from the extrafusal muscle fibers that are innervated by alpha motor neuron (figure 2), where the activation of alpha alone decreases the Ia activity, while the activation of gamma increases the activity of Ia, this occurs to keep the muscle from slacking[13].

Golgi tendon organs (GTO) are another contributor in the processing of proprioceptive information, they are located in muscle tendons (figure 3), GTOs are innervated from Ib sensory axions which carry muscle tension information.

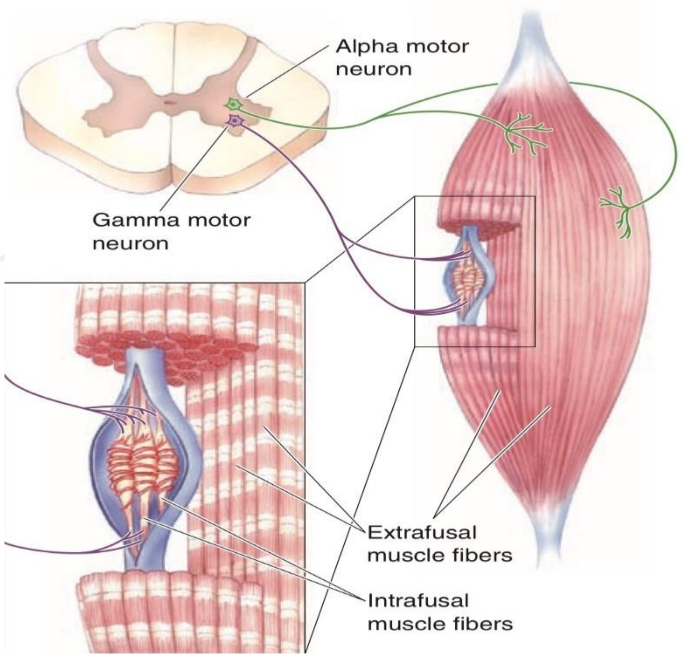

Figure 2 alpha motor neurons, gamma motor neurons and the muscle fibers they innervate.

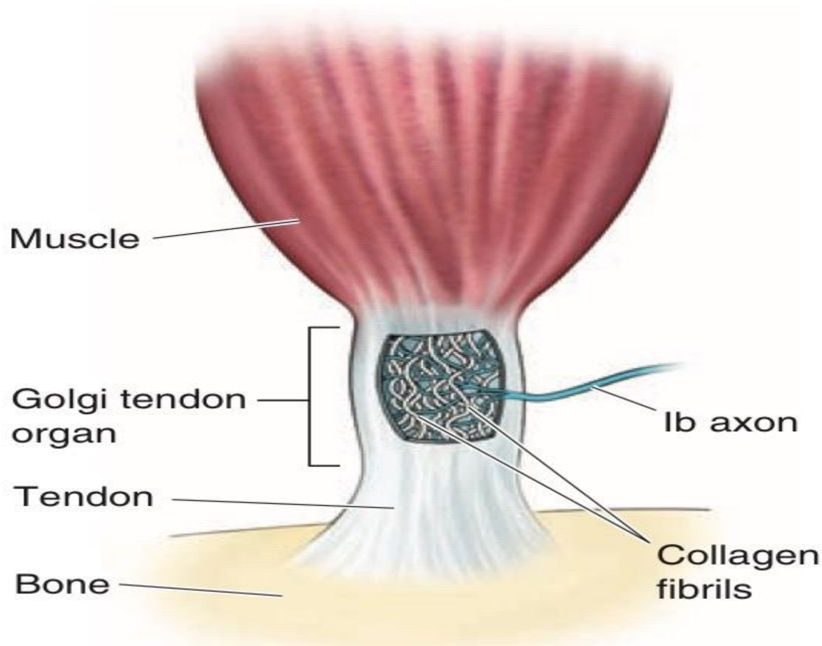

Figure 3 A Golgi tendon organ.

Some Ib axions form inhibitory connection with alpha motor neurons, this happens to protect the muscle from being overloaded, when the muscle tension increases an inhibitory signal from the alpha motor neuron that is sent to decrease the muscle contraction, this is also known as **autogenic inhibition**[13-14].

Reciprocal inhibition is the contraction of one muscle that is followed by the relaxation of the antagonist muscle. This is mediated by descending pathways from the brain to the Ia interneurons that connect to the alpha motor neuron that supply the antagonist muscle, which allows the brain to control the appropriate inhibition required to perform each movement[13-14-15].

Other Mechanoreceptors:

Although muscle spindles and GTOs are the most studied, other mechanoreceptors also contribute to proprioceptive system, such as Skin mechanoreceptors, (figure 4), these receptors vary depending on stimulus frequencies, pressures and receptive fields. For example, Pacinian corpuscle and Ruffini's have large receptive fields where Meissner's corpuscle and Merkel's disk have small receptive fields. Also, the response and adaptation to a stimulus vary, Pacinian corpuscle and Meissner's corpuscle are the first responders to stimulus but they are also the first to stop firing thus they are called rapid adaptors. Merkel's disks and ruffini's endings are slow adaptors[13].

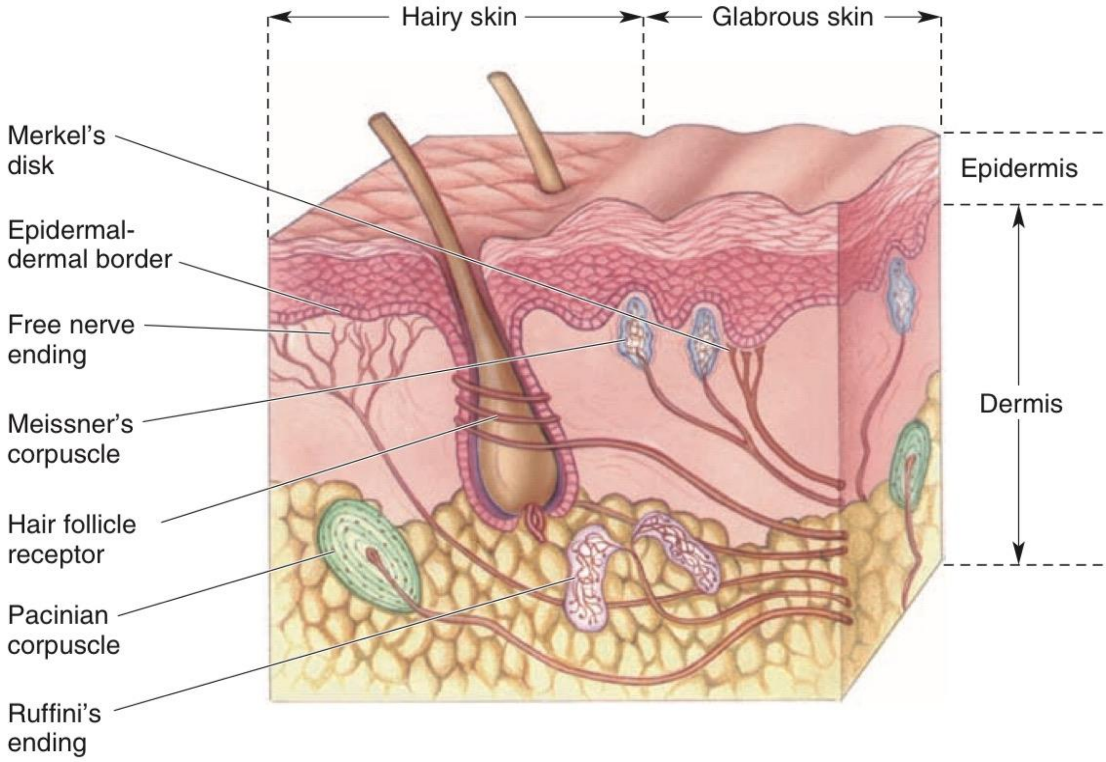

Figure 4 mechanoreceptors between hairy skin and glabrous skin.

2.1.1 Disturbance of Proprioceptors

Disturbed proprioceptors has a poor influence on feedback and feedforward motor control, this causes a decrease in alpha motor neuron drives, decline in balance and increase visual movement error[12].

Disturbance of proprioceptors was linked to many conditions in the musculoskeletal system, pain can cause an alteration in reflex activities and sensitivity of the gamma muscle spindle system via the activation of nociceptors, this was shown in cases such as cervical pain and whiplash injuries[16-17-18-19], other influencers are joint swelling[20], trauma[21] and fatigue[22].

Declined neurological processes were also found to influence proprioception, ageing causes changes in both the central nervous system and peripheral nervous system, these changes lead to decrease in functions of muscle spindles, GTOs and other mechanoreceptors which in turn lead to decrease in proprioception[23], also decreased gray matter and lowered activities in proprioceptive regions of the basal ganglia in older adults were found to decrease proprioception[24]. Also, Proprioception decline was found following stroke[25], Parkinson's disease[26], dystonia[27] and other movement disorders such as chorea tics and Tourette syndrome[28].

2.1.2 Clinical Importance of Proprioception

As discussed, the decline in proprioception is considered a clinical deficit in both musculoskeletal and neuromuscular populations.

Treatment approaches that incorporates proprioceptive training have shown positive results in many conditions. For example, using proprioceptive training with stroke patients have shown to improve gait[29], motor control[30], upper limb[31] and sensorimotor functions[32]. Others used it to improve stability and balance after chronic injuries affecting joints, muscles, tendons and ligaments such as neck pain, ankle instability, Anterior cruciate ligament injuries and knee osteoarthritis[32-33].

A systematic review[32] identified five different approaches to train proprioception in the literature: Sensory discrimination training, somatosensory stimulation training, multiple system training, active movement training, balance training and passive training. They found that the majority of the studies that used the previously mentioned approaches had a positive effect on proprioceptive functions, these were done on healthy adults, stroke Parkinson disease, dystonia and musculoskeletal diseases.

Regarding spinal column, recently there have been reports correlating proprioception with spinal alignment, evidence have shown the involvement of the neuromuscular system as a cause for idiopathic scoliosis by showing abnormalities in the somatosensory and the vestibular system. Although a direct relation between proprioception and scoliosis is yet to be established, a study demonstrated the involvement of proprioceptors in regulating spinal alignment by using genetic mouse models, they were able to establish a link between proprioceptors (specifically Muscle spindles and GTO) and scoliosis[6]. A study applied vibration to four cervical muscles while participants preformed a sequence of stepping in place tests without visual or auditory cues and concluded that disturbed cervical proprioception affects dynamic spatial orientation in healthy participants[34]. Another study showed that neck muscle vibration is an effective technique to improve cervical joint position sense[35], motor imagery combined with motor control exercise influenced cervical joint position error[36].

2.2 Proprioceptive Neuromuscular Facilitation

The mechanism in which PNF produces an effect can vary, with conflicting evidence in the literature a conclusive mechanism can not be drawn, however, the influence in PNF is well established in terms of neurorehabilitation and musculoskeletal rehabilitation[14-37-38].

The initial proposed mechanisms of PNF consist of four neurophysiological principles: 1. Sherrington's law of induction which states that flexion improves extension and extension improves flexion. 2. Sherringto's law of reciprocal inhibition 3. Muscle and joint activities stimulates muscle spindles and GTO activities 4. Irradiation which happens when a maximal contraction of a muscle is achieved by placing resistance on that muscle results in excitation of the primary muscle, which causes overflow to its synergistic muscles to become involved to overcome the resistance on muscle[8-9-39-40]. Note that some of these mechanisms are yet to be completely confirmed or denied [41].

There are many indications for PNF, Table 2 summarizes these indications according to each PNF technique.

On the other hand, contraindications are similar to other treatment approaches, such as unstable bone structures, sever pain, acute injuries in muscle tendons, and the inability to contract muscles isometrically (only applies for some stretching techniques) and with some cancer patients.

Table 2 PNF Techniques Indications.

Techniques	Indications
Rhythmic Initiation	Regulation of muscle tone, uncoordinated movements, arrhythmic movements and tension.
Combination of Isotonics	Decreased control over eccentric contraction, uncoordinated movements, decreased active ROM.
Dynamic Reversals (Incorporates Slow Reversal)	Decrease in active ROM, weak agonistic muscles, inability to change direction of motion, fatigue and hypertonic muscles being relaxed.
Stabilizing Reversals	Decreased stability, weakness, decreased balance, decreased coordination.
Rhythmic Stabilization	Limitations in ROM, joint instability, weak antagonistic muscles, decrease in balance, decrease in coordination.
Repeated Stretch from Beginning of Range	Difficulties in motion initiation due to fatigue, weakness or rigidity, decreased motion awareness.
Repeated Stretch through Range	Weakness, fatigue, decreased awareness of desired motion.
Contract-Relax: Direct Treatment	Decreased passive range of motion.
Contract-Relax: Indirect Treatment	The contraction of the restricted muscles is painful, muscles are very weak to produce contraction.
Hold-Relax: Direct Treatment	Decreased passive range of motion, Pain.
Hold-Relax: Indirect Treatment	Decreased passive ROM, and pain.
Replication	Weakness, inability to sustain a contraction in shortened range.

2.3 Proprioceptive Neuromuscular Facilitation Patterns

Proprioceptive neuromuscular facilitation patterns are a collection of synergistic movements that resemble normal movements and functions by incorporating spiral and diagonal movements in all three plans of motion, there are many aims of PNF patterns including but not limited to, facilitate the ability of the muscles to contract, improve motor control and motor learning, improve strength, enhance coordination and improve proprioception[9-42].

2.3.1 PNF Patterns Mechanisms

When preforming PNF patterns a facilitation component is added such as adding quick stretch, traction, approximation and resistance, these are added to utilize different mechanisms to influence the target areas[9], PNF patterns that use resistance are essentially a type of strength training exercise, but PNF is more concerned with motor unit activation and firing rate, the motor unit provides the primary output for central nervous system by transforming sensory and descending neural inputs to forces that generate movement[43]. It was established that humans can not fully activate muscles voluntarily unless improved by training[44], the neural mechanisms that contribute to neural adaptations are well established in literature, these include the alteration of agonist-antagonist co-activation which is well utilized by PNF patterns techniques[44]. The motor unit firing rate can be influenced by variant conditions that fluctuate this rate in motor unit recruitment, in motor neuron diseases, when tested using surface electromyography (sEMG) patients with stroke exhibited prolonged muscle activation during repeated contraction of the same muscle although this behavior was not seen during incline of the limb or in the holding phase[45]. Also using sEMG to test the properties of motor unit action potential in upper limbs of stroke patients when compared to healthy participants, the results showed differences in the magnitude and rage of motor unit action potentials[46]. In another study on stroke patients they found that ischemic stroke caused a large decrease in the average motor unit recruitment in the sub maximal contraction, sub maximal contractions are used in many of the daily activities, also utilized in some PNF techniques that aim to improve strength[47-9]. This fluctuation is also found in conditions other than stroke, pain related to musculoskeletal conditions was also found to influence the effect of motor output, pain alters motor outputs when the somatosensory cortex produce a pain inhibitory input to the primary motor cortex, not only motor pathways are altered but also afferent pathways including proprioception by modulating the activities of muscle spindles and/or GTOs[(48)]. Increase in muscle fatigue is expected when the motor units decrease, one reason for that is when the firing rate of muscle spindles starts to decrease[(49)], age is another factor that affects the efficacy of the motor unit, because of the compensatory collateral sprouting by surviving neurons in advanced ages, a reduction in motor unit numbers and increased number of muscle fibers per motor unit[(50)]. A study found that patients with mechanical neck pain exhibit less efficient neural recruitment strategies when compared to healthy individuals[(51)].

Multiple studies have established the relation between motor unit recruitment and proprioception, stating that when motor unit recruitment initiate proprioceptive feedback through muscle spindles and GTOs a decrease in the amplitude and increase in the variation of correlation among motor unit firing rates occur (common drive), this occurs regardless of whether the force is constant or linearly increasing. It is possible that the common drive is affected by the ongoing activity of muscle spindles during a contraction. Therefore, muscles with abundance of spindles, exhibit smaller correlation values. The hypothesis that the common drive originates in the central nervous system and decreased by proprioceptive feedback from muscle spindles and GTOs is supported by the findings of this study[(52)], Also, the motor neurons of muscles with large number of spindles receive more negative feedback, which cause a reduction in their firing rates, increase the maximal recruitment threshold and change motor neuron recruitment distribution over the force range[(53)].

A study found that the diagonal movement incorporated by PNF patterns were able to promote cortical adaptation in both of the brain hemispheres therefore influencing cortical organization[(54)], this was similar to another study that demonstrated an increase of alpha absolute power on the left dorsolateral prefrontal cortex and in the superior parietal cortex when participants performed PNF patterns[(55)].

2.3.2 Clinical Effect of PNF Patterns

The effect of PNF patterns is well established in a great deal of the literature in many different areas. In neurorehabilitation PNF patterns are used to restore function, improve strength, balance and gait[37-56-57-58]. In orthopedic and sport rehabilitation PNF patterns are used to decrease pain, increase ROM, strength, improve proprioception, endurance, muscle re-education and so forth[59,60].

Regarding the spinal column, different PNF techniques programs that are aimed to treat low back pain patients resulted in a significant decrease in pain and increased muscle activation[61-62]. This was also supported by another research that used PNF techniques for three weeks on patients with chronic low back pain and resulted in decrease of pain and improvement in functional abilities and static balance[38].

A study compared the effect of PNF patterns with manual therapy on patients with osteoarthritis in the cervical spine and concluded that PNF patterns were more effective than manual therapy in terms of reduction of pain and improving activities of daily living[63]. Also neck PNF patterns were found effective to increase trunk control and balance in chronic stroke patients[64].

2.4 Proprioceptive Neuromuscular Facilitation Stretching

In literature Proprioceptive neuromuscular facilitation stretching can be referred to as contract relax, hold relax and contract relax contract.

Contract relax and hold relax is done by positioning the targeted muscle into a position of stretch, then proceeding with static contraction of the same muscle, then the therapist passively moves it to more position of strength. Contract-relax-agonist-contract technique is done by static contraction of the target muscle, proceeding to a shortening contraction of the target muscle to place it in a new position of stretch, Contract-relax-antagonist-contract (CRAC) involves contraction of the agonist muscle followed by an active contraction of the antagonist to increase ROM[65].

2.4.1 PNF Stretching Mechanisms

The mechanisms underlying PNF stretching effect on ROM are still controversial and undetermined, nevertheless, PNF stretching has four proposed mechanisms: autogenic inhibition, reciprocal inhibition, stress relaxation and the gate control theory.

As mentioned in earlier section autogenic inhibition is a sort of protective mechanism of muscles in which the GTOs in a muscle send inhibitory signals when a muscle is over stretched or contracted, CRAC is thought to take advantage of this mechanism[14,66].

Reciprocal inhibition occurs when a muscle is contracted, an inhibitory single is sent to the opposing muscle to relax allowing the contracted muscle to have more ROM, this could explain what occurs during “antagonist-contract” portion of CRAC[66,67].

Stress relaxation is initiated when the musculotendinous unit (MTU) is placed under constant stress, muscles and tendons have viscoelastic properties in which they exhibit features of viscous and elastic materials. The viscoelastic material is seen when the MTU is placed under stress to resist sear flow and strain linearly, when the stress is removed it returns to the original form. When the viscous material loses its capability to resist the stretch over time, the MTU slowly increases in length, this process is called the creep of the MTU. This is employed by the contract relax technique when the contraction of the targeted muscle increases the tensile stress acting on the MTU causing the creep reaction of the muscle which enhances the ROM of that muscle[14].

The gate control theory is what occurs when two different stimulus activate their receptors such as when pressure and pain are stimulated, in contract relax and CRAC, the muscle is stretched past its active ROM, then the participant is told to resist against the stretch position, moreover, the target muscle is stretched even further. A huge force and stretch are produced in the lengthened muscle when the participant resists the stretch. This huge force is sensed as noxious stimuli, and perceived as a potentially damaging force, which provokes the GTOs to activate in an attempt to inhibit the force and prevent injury to the muscle or the tendon. A repetition of this process will decrease the inhibition effect, which will allow the muscle and tendon to be accustomed to the newly acquired length[14].

2.4.2 The Clinical Effect of PNF Stretching

PNF stretching is a widely used technique in musculoskeletal conditions to improve ROM.

The clinical application of PNF stretching was investigated and compared to other stretching techniques for its effect on ROM. A systematic review found low to moderate quality evidence for PNF stretching to improve ROM in healthy adults[68]. Also a trial on hockey players found no improvement for active ROM of the hip and knee when using PNF stretching, on the contrary another systematic review found that PNF stretching was effective in increasing hip joint ROM although static stretching had the same results[69], also PNF stretching was found to have a positive effect on young soccer players in regards to improving ROM and Kicking speeds[70], PNF stretching was found effective to improve ROM in patient population[14-65-71], where some studies concluded that PNF stretching is effective in increasing the ankle joint ROM in conditions affecting the ankle joint or the foot[72-73], PNF stretching are widely used to improve hamstring flexibility, this is supported by multiple studies that found positive results in using PNF stretching to improve hamstring flexibility for short and long terms in both healthy and patient populations[74-75-76-77-78-79].

The effects of PNF stretching goes more than its effect on ROM, for instants , there have been some evidence where PNF stretching improved dynamic balance this effect was found to be immediate or lasting for a week[80-81-82], in regards to physical performance controversial results were found, on one hand some studies found that preforming PNF stretching before exercise can decrease physical performance, on the other hand, this decrease seems to fade after 10 minutes unless prolonged stretching was performed, therefore, PNF stretching is not strongly recommended before sports that require explosive force such as short track running, jumpers[68-83-84] , the effect of PNF stretching on cervical spine was poorly documented in the literature, where most studies found the effect of other types of stretching mostly on knee joint except one study that used PNF stretching (hold relax) and found an insignificant difference indicating that the reason might be due to the healthy participants[(81)].

2.5 Assessment of Proprioception

As mentioned earlier the variability of neurophysiological processes that occur to construct proprioception makes assessing it a hard task for clinicians and researchers, one systematic review that included 57 articles was able to identify 32 test of proprioception[(85)], nonetheless, three main testing techniques were reported in the literature for assessing proprioception, the first being threshold to detection of passive motion (TTDPM), second is joint position reproduction (JPR) also named joint position matching, third is active movement extent discrimination assessment (AMEDA) [(86)], each technique uses different procedures and different devices depending which mechanism or body part is being tested. Comparison of these techniques can be found in table 3.

TTDPM tests are done using various procedures, some used robotics or motorized devices, special splints or the tester passively moving the limb, then participants are asked to inform the tester when they first feel the movement and in which directions with visual and auditory feedback is blocked and the degree in which the participants perceive the motion and the start of motion are recorded[(87)].

JPR can be done using ipsilateral JPR where participants are either passively or actively moved to a certain degree then back to neutral position and then participant are asked to reproduce the target joint angle. For contralateral JPR, the first method is similar to ipsilateral JPR but the participant is asked to reproduce the movement using the contralateral limb, the second method is done by moving the joint to a target position and maintain that position then participant is instructed to reproduce the movement in the contralateral joint. [(87)]

Table 3 Comparison Of Protocols Used In TTDPM, JPR, And AMEDA Proprioception Tests.

Proprioception test	TTDPM	JPR	AMEDA
Movement type	Passive	Passive/active	Active
Movement speed	Very slow	Slow/normal	Normal
Familiarization trial number	Unfixed	Unfixed	Fixed, 15 trials
Testing trial number	3–5 correct answers	Usually 3–5, up to 10 trials	50
Movement difference between familiarization and testing	No	Depends on the types of movement used in target joint position establishment and reproduction	No
Proprioceptive information	Largely movement information	Depends on whether a physical stop is used during target joint position establishment	Both movement and position information
Vision	Blocked	Blocked	Available
Audio	Blocked	Available	Available
Posture	lying or sitting	lying or sitting	Standing
Constrain	Usually constrained	Usually constrained	No constrains
Weight-bearing	none or partial weight-bearing	None, partial or normal weight-bearing	Normal weight-bearing
Measurement	Difference between the start position and responded position	Error between the target position and performed position	AUC score
Unit	Degree	Degree	AUC score
Testing duration	Up to 6 h	Depends on the number of trials used	10 min

TTDPM = threshold to detection of passive motion; JPR = joint position reproduction; AMEDA = active movement extent discrimination apparatus; AUC = area under the curve.[86]

AMEDA is done with active functional movements using AMEDA set-up, participants are given a familiarization trial before collecting the data, then told that there will be five movement displacement distances from the smallest to the largest for three times and 15 in total, for example when testing the ankle joint, the tested foot is placed on an axel beneath, running in the long inversion movements on the tilt plate, from horizontal position down to a determined stop point then the participant is asked to return to the horizontal position, the participants are asked which position they stopped at for every tested movement without feedback about the correctness of the answer[88]. Figure 5 shows the different apparatus of the 3 assessment methods.

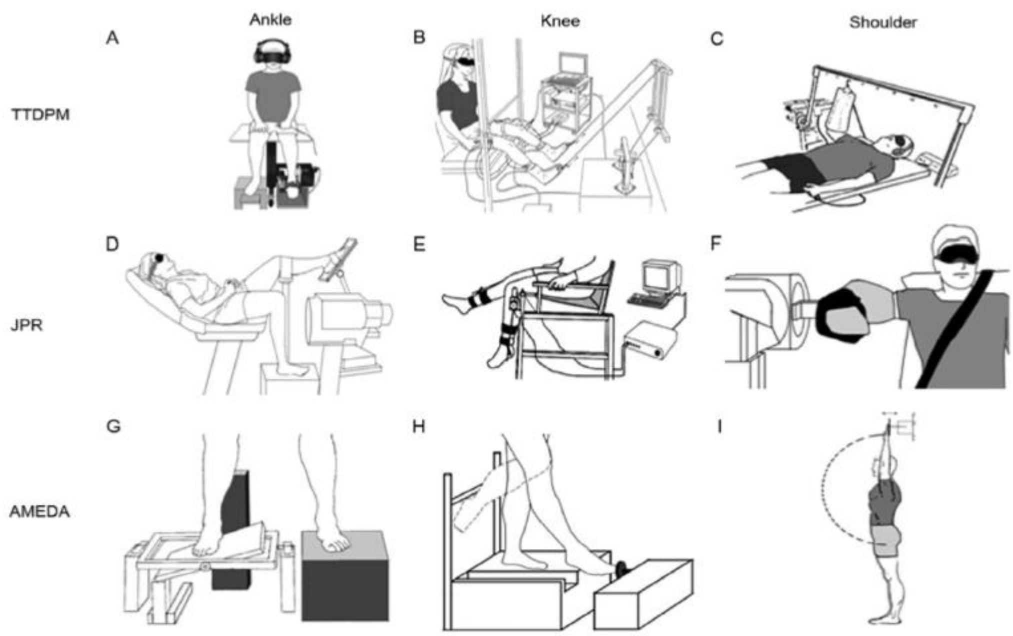

Figure 5 Comparison of Different Apparatus Employed in Threshold to Detection of Passive Motion (TTDPM), Joint Position Reproduction (JPR), and Active Movement Extent Discrimination Apparatus (AMEDA) Proprioception Tests, at the Ankle, Knee, and Shoulder

For cervical proprioception testing the two common methods in clinical practice are TTDPM and JPR with their various techniques, it is noteworthy to mention the factors that can influence the results of these tests. Skin contacts might influence joint position sense assessment, thus, the examiner should keep contact with the participants skin as minimal as possible, this is important when performing passive tests[89]. Also, the delay effect on some techniques, for example the delay between passive test and ipsilateral matching response can cause less effective results. Also, with participants with poor memory the time between the movement and the response should be at minimum. Muscle fatigue is another factor that influences the results of proprioception testing. Passive and active movement with reproducing the movement is also a factor because of the difference in sensory inputs that occurs during passive or active movements, in general using active movements is recommended because they involve both joint and muscle receptors[90].

2.6 Common Interventions on Cervical Proprioception.

Few methods to improve cervical proprioception can be identified in the literature, here are some examples:

1. Head relocation training: by relocating the head to a predetermined position in range can be done with eyes closed and/or without[91].
2. Eye follow and gaze stability: done by moving the eyes while the head fixed and moving the head while the eyes fixate on a target[92].
3. Eye head coordination: is done by moving the eyes and the head to the same direction, then progress to moving the eyes first then follow it with the head to the same direction, then can progress by moving the eyes first and the head to look between two targets in horizontal or vertical orientation, difficulty can be increased by having the eyes and the head move in opposite directions or by increasing the movement speed and directions[91].
4. Neck muscle vibration: is done using vibration devices and target specific or group of muscle for different lengths of time[35].
5. Motor imagery and action observation: motor imagery is done by asking the participant to imagine doing one of the above methods without

producing any movement, while action observation is the same but the participant is asked to watch the investigator or recorded video of the methods also without producing the movement[35].

Head relocation, eye-follow and gaze and eye/head coordination was found to be effective to improve joint position sense in patients with chronic neck pain[91].

A study assessed neck muscle vibration on joint position sense and postural control on patients with neck pain and control group, the results showed that joint position sense and postural control improved after neck muscle vibration but in healthy subjects the opposite occurred, their joint position sense and postural control actually decreased[93]. This was also shown by a pilot study that used whole body vibration and found increase in neck joint position error[94].

Motor imagery and action observation were found effective in improving cervical joint position in patients with chronic neck pain when compared to muscle vibration[35], another study used motor control exercise and combined with motor imagery and action observation can significantly change joint position error[36].

3. METHODS AND MATIRIALS

This research was approved by Medical Ethics Committee of Medical, Surgical and Drug Researches of Yeditepe University Medical Faculty (Registration no: 1656 Decision no: 1028). Appendix 1.

3.1 Study Design

This is a double-blinded randomized controlled trial. Participants were not aware of their assigned group, also the assessor was blinded to group allocation.

3.1.1 Sample Size

The sample size was calculated by using G*Power 3.1.7 for Windows (G*Power©, University of Dusseldorf, Germany), by using f family test ANOVA repeated measures and between factors, with statistical power of 0.80 (1-B error Probability) and alpha error level probability of 0.05 and effect size of 0.25 with number of measurements being 2, which total to 120 participants.

A total of 158 participants were evaluated for inclusion criteria, only 104 meet the inclusion criteria and were randomly allocated to the groups. See figure (6) for participants allocation.

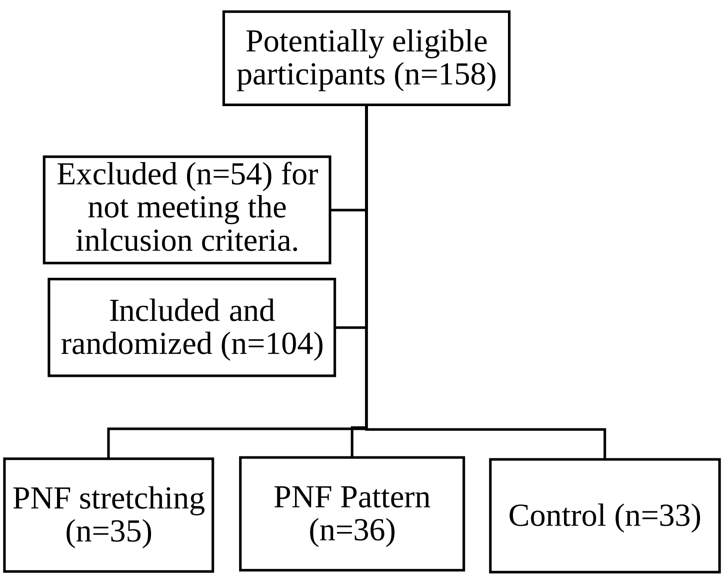

Figure 6 Flow Chart of Participants Allocation and Randomization.

3.2 Participants

We recruited participants from university campus by directly asking students from classes if they can volunteer by explaining that the trial will involve the cervical region, also mentioned that is one-time session that can take up to an hour. Participants then were handed consent forms that included more details about the trial. Appendix 2

3.2.1 Inclusion Criteria

The inclusion criteria were: To determine if a participant is healthy a score of 5 or less on the neck disability index was used[(95,96]), no history of cervical trauma, rheumatic diseases, whiplash syndrome, no history of surgeries to the neck, face and shoulders, no history of cancer, no history of systemic diseases, age of 18 or above and able to understand and follow instructions.

3.2.2 Randomization and Procedures

Randomization was done by a person external to the study.

Participants that signed the consent form and meet the inclusion criteria were assigned a number which corresponded to one of the 3 groups.

Participants were asked to enter a room where the assessor preformed the first measurements, then participants were asked to go to a separate room where the treatment methods took place. The therapist corresponded the number of the participant to the randomization sheet and applied the assigned treatment. After that participants were asked to go back to the first room for the second measurement. Participants were asked not to make a comment to the assessor but they can direct any question to the therapist.

3.3 Statistical Methods

Statistical analysis was done using ‘Statistical Package Analyze for Social Sciences’ (SPSS) version 23.0 for windows. The variables were analyzed using probability plots and Shapiroe Wilks test to test the normality of the distribution. Descriptive analysis were presented with mean and standard deviation (SD), and frequency tables for the ordinal variables. The Wilcoxon test was performed to test the significance of pairwise differences using Bonferroni correction to adjust for multiple comparisons, Kruskal-Wallis test was used to compare the groups. The level of significance were accepted as $p \leq 0.05$

3.4 ASSESSMENT METHODS

The following outcome measures were taken before and after the intervention.

3.4.1 Cervical Proprioception

The cervical proprioception was done using cervical range of motion instrument (CROM, Performance Attainment Associates, Lindstrom, MN, USA), the device is made of a plastic frame that rest over the head, nose and ears, with a strap to secure it, it has three inclinometers attached to the frame, one in the sagittal plane, the second in the frontal plane and the third in the horizontal plane, which makes able to measure all 6 directions of movement. This instrument was reliable and valid to assess cervical proprioception, the chosen target angle is 30 degrees[97-98-99].

Cervical proprioception was done for flexion, extension, right side bending, left side bending, right and left rotation.

Participants were asked to sit and put on the CROM instrument, then they were instructed to start moving their head to one of directions then the assessor stopped them at 30 degrees and told them to feel the amount of movement and muscle tension, this was repeated 3 times as a reference, then they were asked to do the movement with the eyes closed until they reach the target angle, this was repeated for 3 times, this was done for each direction and the assessor recorded the results.

3.4.2 Range Of Motion and Muscle Strength

Active Range of motion (AROM) was measured using CROM instrument, the validity and reliability of CROM to assess ROM is well documented in the literature, AROM was taken for all movement directions[100,101].

Muscle strength was taken using a myometer device (microFET2™ Hoggan Health Industries, Inc, West Jordan, Utah).

3.5 Intervention Methods

As discussed earlier, participants were allocated to three groups, these are PNF pattern, PNF stretching and a control group.

3.5.1 PNF Patterns

PNF patterns were performed using Dynamic of reversals technique which is characterized as active motion alternating from one direction (agonist) to the opposite (antagonist) without relaxing. The cervical patterns consisted of

1- Cervical flexion with right rotation followed by extension with left rotation.
2- Cervical flexion with left rotation followed by extension with right rotation.

The participants were asked to sit on a chair, the therapist performed the pattern of movement himself then passively applied the pattern on the participant then asked the participant to perform the pattern, and the therapist observed and corrected the movement if it was done improperly. Then participants were told that the therapist will resist their movement, they were also told to keep breathing normally and to report any discomfort and/or pain.

After mastering the pattern, the therapist placed one hand on the participant's mandibular and the other hand approximately between parietal and occipital bones to apply resistance throughout the ROM. See figure 7, each pattern performed for 3 sets of 10 repetitions with 1-2-minute rest between sets.

3.5.2 PNF Stretching

PNF stretching was done using contract-relax-antagonist contract (CRAC) technique for cervical flexors, extensors, right and left lateral flexors, right rotators and left rotators. This was done for 6 repetitions with hold for 6 seconds in position of stretch and submaximal isometric contraction for 6 seconds, 1-2-minute rest was given before changing the target muscle group[(65)]. Figure 8

3.5.3 Control

Participants allocated to the control group received ineffective passive ROM for 10 repetitions for flexion, extension, right and left side bending and right and left rotation, it was done from neutral position to the limit of motion without causing any stretch to the muscle. This was done to keep the participants blinded to the group allocation.

Figure 7 PNF Pattern starting position (left) and end position (right).

Figure 8 PNF Stretching Starting Position (Left) and End Position (Right), the Red Arrows Indicate Direction of Resistance.

4. RESULTS

Statistical analysis was done using ‘Statistical Package Analyze for Social Sciences’ (SPSS) version 23.0. The level of significance were accepted as $p \leq 0.05$.

The distribution of gender is shown in table 4, the groups showed no significant difference in gender (Chi-Square Tests p= 0.0.413).

Age, height, weight and BMI values showed no significant difference ($p>0.05$). As shown in table 5, other characteristics are shown in table 6.

Table 4. Gender distribution between groups

		PNF Stretching	PNF Pattern	Control	Chi-square	P-value
Gender	**Female**	19	23	23	1.767	0.413
	Male	16	13	10		

Table 5. Physical characteristics of the groups

		PNF Stretching (n=35)	PNF Pattern (n=36)	Control (n=33)	Chi-square	p
Age (Years)	Min-Max	19 – 28	20 – 28	19 - 26	4.590	0.101
	Mean (SD)	22±3	22±2	21±2		
Height (m)	Min-Max	1.50 – 2.05	1.55 – 1.87	1.57 - 1.93	0.551	0.759
	Mean (SD)	1.72±0.10	1.71±0.08	1.71±0.10		
Weight (kg)	Min-Max	46 – 107	50 – 117	40 - 120	0.580	0.748
	Mean (SD)	69±17	69 ±14	67±17		
BMI (kg/m^2)	Min-Max	15.92 – 35.83	18.47– 33.82	16.02 - 35.06	0.724	0.742
	Mean (SD)	23.17±4.56	23.36±3.59	22.66±4.41		

BMI: Body Mass Index, Data demonstrated as mean and Standard Deviation.

Table 6. Participants dominant side, smoking and alcohol habits, medical history and exercise habit. (count)

		PNF Stretching	PNF Pattern	Control
Dominancy	**Right**	30	35	26
	Left	5	1	7
Smoking	**Never**	22	19	20
	Quit	5	3	3
	Yes	8	14	10
Alcohol	**No**	8	13	14
	Only special days	15	12	8
	Several times a month	9	7	10
	Few times a week	3	4	1
	Regularly everyday	0	0	0
Diseases	**No**	26	31	27
	Rheumatismal	0	1	0
	Orthopaedic	1	2	1
	Neurologic	0	1	0
	Different type	8	1	5
Medication	**No**	30	35	29
	Antihistaminic	3	0	0
	Exjade	0	1	0
	Kreon	1	0	0
	Bronchodilator	1	0	0
	Antidepressant	0	0	1
	Glucophage	0	0	1
	Levotiroksin	0	0	1
	Spironolactone	0	0	1
Surgery	**No**	29	25	23
	Tonsillectomy	2	4	3
	Rhinoplasty	2	3	3
	Appendicitis	0	2	2
	Splenectomy	0	1	0
	Orthopedic-Lower Extremity	1	0	0
	Orthopedic-Upper Extremity	1	1	0
	Inguinal Hernia	0	0	1
	Heart Surgery	0	0	1
Exercise Habit	**No**	13	16	15
	Less than 3 days	12	11	13
	3 days or more	10	9	5

4.1. Proprioception:

Before intervention there was no significant difference between groups in cervical proprioception deviation from target angle (30 degrees) in all movement directions ($p>0.05$). Table 7

Table 8 shows comparison of the difference of cervical proprioception deviation from target angle before and after intervention within each group and between groups.

The level of significance within each group for the deviation from target angle before and after the intervention for each movement direction, showed significant difference only in extension ($p= 0.010$) in PNF stretching group, where in the PNF pattern group significant differences were found in extension ($p=0.018$), right rotation ($p= 0.009$), right side bending ($p= 0.005$) and left side bending ($p= 0.001$), the control group showed significant difference movement in flexion ($p= 0.004$), extension ($p= 0.014$), right rotation($p= 0.002$) and right side bending (0.010) (see table 8).

Also table 8 shows that there is no significant difference between groups in all movement directions ($p>0.05$).

Table 7. Comparison of cervical proprioception deviation from target angle between Groups before intervention.

	PNF Stretching	PNF Pattern	Control	Chi-square	P value between groups
	Mean(S.D)	Mean(S.D)	Mean(S.D)		
Flexion	2.11±2.22	2.00±2.24	3.33±2.81	5.739	0.057
Extension	3.31± 3.14	2.44 ±1.85	2.97± 2.78	0.564	0.754
Right rotation	3.37± 3.31	2.94±2.76	3.45± 3.01	0.715	0.699
Left rotation	2.80± 3.18	1.94 ±1.99	3.21 ±2.73	3.776	0.151
Right side bending	2.86± 2.29	3.06± 2.55	3.21± 2.23	0.651	0.722
Left side bending	1.83± 2.07	2.39 ± 2.23	2.52± 2.03	2.342	0.31

N: number, S.D: Standard deviation. Min: minimum Max: Maximum

Table 8. Comparison of the difference of cervical proprioception deviation from target angle before and after intervention within each group and between groups.

	PNF Stretching		PNF Pattern		Control		Chi-square	P value between groups
	Mean(S.D)	Within group	Mean(S.D)	Within group	Mean(S.D)	Within group		
Flexion	2.40±1.86	0.221	1.83±2.10	0.539	2.97±2.65	**0.004***	5.46	0.065
Extension	2.46 ±2.66	**0.010***	1.83 ±1.54	**0.018***	2.18±2.20	**0.014***	0.473	0.065
Right rotation	3.26± 3.22	0.52	2.72± 2.35	**0.009***	2.73±2.44	**0.002***	0.454	0.065
Left rotation	2.29± 2.83	0.22	1.89 ±1.78	0.244	2.30±2.18	0.132	0.503	0.065
Right side bending	2.51± 2.24	0.65	2.17±2.10	**0.005***	2.42±2.16	**0.010***	0.466	0.065
Left side bending	2.17± 2.07	0.683	1.78 ± 1.77	**0.001***	1.85±1.97	0.104	0.716	0.065

N: number, S.D: Standard deviation. Standard deviation. Min: minimum Max: Maximum * indicating significant results $p < 0.05$

4.2. Range of Motion:

Before intervention there was no significant difference between groups in cervical ROM in all movement directions (p>0.005). Table 9

Comparison of the difference of cervical ROM before and after intervention within each group and between groups was done. Table 10

The level of significance within the PNF stretching group showed significant difference in right rotation (p=0.037), where the rest of movement directions showed no significant difference (p>0.05). Table 10

The level of significance within the PNF pattern group showed significant difference in extension (p=0.007) and right rotation (p=0.001), where the rest of movement directions showed no significant difference (p>0.05). Table 10

The level of significance within the Control group showed significant difference in extension (p=0.037), right side bending (p=0.020) and left side bending (p=0.014), where the rest of movement directions showed no significant difference (p>0.05). Table 10

There was no significant difference between groups in all movement direction (p>0.005). Table 10

Table 9. Comparison of cervical ROM between Groups before intervention.

	PNF Stretching	PNF Pattern	Control	Chi-square	P value between groups
	Mean(S.D)	Mean(S.D)	Mean(S.D)		
Flexion	2.11±2.22	2.00±2.24	3.33±2.81	1.240	0.057
Extension	3.31± 3.14	2.44 ±1.85	2.97± 2.78	0.927	0.754
Right rotation	3.37± 3.31	2.94±2.76	3.45± 3.01	0.724	0.699
Left rotation	2.80± 3.18	1.94 ±1.99	3.21 ±2.73	0.201	0.151
Right side bending	2.86± 2.29	3.06± 2.55	3.21± 2.23	1.696	0.722
Left side bending	1.83± 2.07	2.39 ± 2.23	2.52± 2.03	1.766	0.31

N: number, S.D: Standard deviation. Min: minimum Max: maximum.

Table 10. Comparison of the difference of cervical ROM before and after intervention within each group and between groups.

	PNF Stretching		PNF Pattern		Control		Chi-square	P value between groups
	Mean(S.D)	Within group	Mean(S.D)	Within group	Mean(S.D)	Within group		
Flexion	6.51±5.14	0.13	5.16±4.90	0.245	5.45±3.84	0.473	1.782	0.41
Extension	6.54±4.44	0.532	5.33±6.10	**0.007***	4.72±3.76	**0.037***	4.953	0.84
Right rotation	5.22±4.64	**0.037***	6.00±4.51	**0.001***	4.66±4.26	0.118	2.372	0.305
Left rotation	4.91±4.91	0.111	4.13±3.56	0.344	4.42±3.86	0.15	0.147	0.929
Right side bending	4.54±3.50	0.407	3.61±3.23	0.771	4.06±3.44	**0.020***	1.237	0.539
Left side bending	3.74±2.82	0.224	3.33±3.06	0.143	4.66±3.068	**0.014***	3.800	0.15

N: number, S.D: Standard deviation. * indicating significant results $p < 0.05$

4.3. Strength:

Before intervention there was no significant difference between groups in cervical muscle groups in all movement directions (p>0.005). Table 11

Comparison of the difference of cervical muscle groups strength before and after intervention within each group and between groups was done. Table 12

The level of significance within the PNF stretching group showed no significant difference in all movement directions (p>0.005). Table 12

The level of significance within the PNF pattern group showed significant difference in right rotation (p=0.003) and left rotation (p=0.004), where the rest of movement directions showed no significant difference (p>0.005). Table 12

The level of significance within the Control group showed no significant difference in all movement directions (p>0.005). Table 12

The between groups level of significance showed significant difference in left rotation (p=0.006), where pairwise comparison showed significant difference between control-PNF stretching (p=0.012) and between control-PNF pattern (p=0.020) but not between PNF pattern-PNF stretching (p=1.000). Table 13

The rest of movement directions showed no significant difference (p>0.005). Table 12

Table 11. Comparison of cervical muscle groups strength between Groups before intervention.

	PNF Stretching	PNF Pattern	Control	Chi-square	P value between groups
	Mean(S.D)	Mean(S.D)	Mean(S.D)		
Flexion	13.03±4.93	12.73±4.59	12.46±4.60	0.205	0.903
Extension	19.32±5.98	19.59±7.45	18.76±5.91	0.175	0.916
Right rotation	12.94±3.00	12.22±3.06	11.68±3.37	3.159	0.206
Left rotation	12.40±3.37	12.29±5.12	11.99±4.04	0.649	0.723
Right side bending	17.65±5.53	18.53±6.14	17.33±5.49	0.490	0.783
Left side bending	17.0±5.10	17.84±6.38	16.29±6.18	1.138	0.566

N: number, S.D: Standard deviation. Min: Minimum Max: Maximum

Table 12. Comparison of the difference of cervical muscle groups strength before and after intervention within each group and between groups.

	PNF Stretching		PNF Pattern		Control		Chi-square	P value between groups
	Mean(S.D)	Within group	Mean(S.D)	Within group	Mean(S.D)	Within group		
Flexion	2.17±1.99	0.957	1.65±1.41	0.844	1.76±1.13	0.07	0.752	0.687
Extension	2.79±2.32	0.756	2.68±2.41	0.11	2.80±1.81	0.304	0.703	0.703
Right rotation	2.29±2.07	0.664	1.98±1.59	**0.003***	1.46±1.12	0.126	3.274	0.195
Left rotation	2.18±1.74	0.589	2.65±4.38	**0.004***	1.24±1.39	0.242	10.323	**0.006***
Right side bending	2.30±2.34	0.327	2.46±2.15	0.426	5.70±21.30	0.098	0.151	0.927
Left side bending	2.77±2.35	0.583	3.03±2.31	0.814	2.48±1.74	0.114	0.666	0.717

N: number, S.D: Standard deviation. Min: Minimum Max: Maximum * indicating significant results p <0.05

Table 13 comparison between groups for left rotation muscle strength

Group	**Chi-square**	P-value
Control-PNF Pattern	19.729	**0.020***
Control-PNF stretching	21.038	**0.012***
PNF pattern-PNF stretching	1.309	1.000

* indicating significant results p <0.05

5. DISCUSSION

The aim of the study was to investigate the effect of two types of PNF techniques 1. PNF stretching 2. PNF patterns on cervical proprioception, ROM and strength of healthy adults. To the best of our knowledge this is the first study with this aim.

In a study that aimed to investigate the effect of age, gender and BMI on cervical movements in 120 healthy participants found that with the increase of age there was decrease in cervical movements, where gender and BMI had less influences on cervical movements[(102)].

Another study investigated the effect of age and gender on cervical ROM and proprioception in 140 healthy participants found that age does decrease ROM and proprioception, where gender did not have a significant influence except on ROM in the ages “70-79”[(103)].

In this study the minimum age of the participants was 19 and the maximum of 28 with no significant difference between groups, this rules out that age had influence on the results. Also gender, height, weight and BMI did not show significant difference between groups.

In this study PNF stretching did not show a significant difference when compared to the groups in all outcome measures, except for left rotation muscle strength.

Some studies on other body regions have similar results to this study, a study that used hold relax PNF stretching technique on hip flexors and their influence on knee proprioception found that PNF stretching did not influence proprioception[(81)], where another study that used the same technique on hamstring and quadriceps concluded that PNF stretching reduces knee proprioception[(104)].

In this study, although PNF stretching did not show significant difference when compared to other groups, the within PNF stretching group analysis, shows that PNF stretching improved extension.

This conflict of results can be due to the difference in proprioception assessment techniques and the different PNF stretching protocols, this was also concluded in a recent systematic review that stated the lack of similar PNF techniques and outcome measures making it difficult to draw conclusion on the effect of PNF stretching on proprioception[105].

The results also puts the proposed mechanisms of PNF stretching into question, these being the influence of PNF stretching on GTOs and muscle spindles, since both are accepted mechanisms for proprioceptive information acuity[4,6], and the results of a study that used EMG to investigate the mechanisms of PNF stretching on hamstring, with results indicating no presence of reciprocal inhibition (muscle spindle involvement) or autogenic inhibition (GTOs involvement)[106], also our study shows the lack of significant difference in 5 out of 6 movement directions within the PNF stretching group on cervical proprioception, therefore, different theories for the mechanisms of PNF stretching should be proposed.

Most studies investigated the effect of PNF stretching on ROM were done on lower limb muscles, a systematic review that compared the effect of PNF stretching with other stretching techniques in healthy young adults found low to very low evidence of PNF stretching over other techniques[107]. This is in line with results of PNF stretching group in this study, which did not show significant difference in cervical ROM when compared to PNF pattern group and the control group and with only within group significant difference in right rotation. This should be interpreted carefully since these results are on healthy young participants, where there is a great deal of evidence of the effect of PNF stretching on ROM in patient population as mentioned earlier.

In this study, there was no indication that PNF stretching had influence on cervical muscles strength within the PNF stretching group and only a significant difference in left rotation strength over control group but not when compared with PNF pattern.

This was in line with a study that investigated the influence of PNF stretching on muscle maximal voluntary contraction and found that PNF has no effect on it in healthy participants[108]. Also a systematic review reported that 16 non-significant findings studies and only 3 studies reported reduction in muscle strength[68]. As in their study, Konrad et al. reported loss in maximal isometric torque after PNF stretching (CRAC) using 15 second static stretching and 6 seconds for submaximal isometric contraction for the ankle joint[109].

This loss in strength in Konrad et al. study and the lack of difference (except of left rotation) in our study can be due to CRAC technique which places the muscles in a stretch position and cause isometric contraction in both the agonist and the antagonist muscle, which might cause muscle fatigue and in turn less muscle contraction when tested immediately after the implementation of the exercise.

In this study PNF pattern group did not show any significant difference when compared to other groups in all outcome measures, except for left rotation muscle strength.

The influence of PNF patterns on cervical proprioception is not present in the literature, only one study was found that applied PNF pattern on the cervical region to test its influence on trunk control and balance in stroke population[64].

In our study, although PNF patterns did not show significant difference in proprioception between groups, it showed significance within group analysis for 4 out of the 6 test movement directions. These results can be expected since we only tested the acute effect, where PNF patterns are usually applied over multiple sessions.

The effect of PNF patterns on cervical ROM is also not present in the literature, however, there are multiple studies on other body regions as mentioned earlier, in our study PNF pattern group had within group significance in 2 out of the 6 tested muscle groups.

Youdas et.al. Used EMG to investigate muscle activation during PNF patterns for upper limb and found high muscle activations in almost all tested muscles, which indicates higher ability to gain strength[60].

In the present study a significant difference over the control group was found only in left rotation muscle groups, the within group significance was found in right rotation and left rotation muscle groups, this might be because right rotators and left rotators were the weakest before intervention, also muscle strength gain occurs with higher session over weeks[110].

Unexpectedly the control group showed within group significant difference on proprioception in 4 out of the 6 test movement directions, this was similar to the number of significant differences found within the PNF pattern groups and even better than the significance found in the PNF stretching group.

Also the control group had better within group differences in ROM than PNF stretching and PNF pattern group, this was not seen regarding muscle strength where the control group did not have any significant difference within group and worse results in left rotation muscle strength when compared to PNF stretching and PNF pattern.

A possible reason for the results in the control group can because the control only underwent passive ROM without causing any stretch effect which did not cause any strain on muscles and allowed the participants to be less fatigued and perform better in proprioception testing and ROM but not in muscle strength which requires higher muscle activation.

The presence of significant difference within group in both PNF stretching and PNF pattern groups indicates that if these techniques are applied over more sessions, it can yield in more significant results in more movement directions.

Moreover, PNF pattern group was the only group out of the three groups to have a within group significance in at least two movement directions in all outcome measures, indicating that it is a promising technique in influencing cervical ROM, strength and proprioception.

There is a lack of studies in the literature regarding the use of PNF on cervical proprioception and with the data in this study suggest the need for further investigation for the use of PNF on cervical region and also the neurophysiological mechanisms behind the use of PNF techniques.

Future studies should be done for more than one session to be able to draw more conclusive results, also using different PNF stretching protocols in terms of stretch duration or different PNF stretching techniques, although this study had a sizable sample, future studies can benefit of a larger sample and more equal distribution of the study groups.

6. CONCLUSION

In conclusion, we did not find a significant influence of PNF stretching on cervical proprioception and range of motion, only an improvement of left cervical rotation muscles strength over the control group but not when compared to PNF pattern group, also PNF stretching had the least influence on outcome measures in the within the group analysis, where it only influenced extension proprioception and right rotation range of motion.

PNF pattern showed more promising results, although it had only significant difference over the control group in left rotation muscles strength and not over PNF stretching group, it had more significant differences in the within the group analysis compared to the other groups, where it showed improved extension, right rotation, right side bending and left side bending proprioception, extension and right rotation range of motions, right and left rotator muscles strength.

The current data does not support the use of PNF stretching and PNF pattern to influence cervical proprioception, range of motion and strength. Future trials should be done over longer periods of time to get more conclusive results.

REFERENCES

1. Muscolino JE. *Kinesiology: The Skeletal System and Muscle Function*. Mosby/Elsevier; 2014

2. Armstrong B, McNair P, Taylor D. Head and neck position sense. [Review] [154 refs]. *Sport Med*. 2008;38(2):101-117.

3. Fejer R, Kyvik KO, Hartvigsen J. The prevalence of neck pain in the world population: A systematic critical review of the literature. *Eur Spine J*. 2006;15(6):834-848. doi:10.1007/s00586-004-0864-4

4. Kröger S. Proprioception 2.0: novel functions for muscle spindles. *Curr Opin Neurol*. 2018;31(5):592-598. doi:10.1097/WCO.0000000000000590

5. Proske U. Kinesthesia: The role of muscle receptors. *Muscle and Nerve*. 2006;34(5):545-558. doi:10.1002/mus.20627

6. Blecher R, Krief S, Galili T, et al. The Proprioceptive System Masterminds Spinal Alignment: Insight into the Mechanism of Scoliosis. *Dev Cell*. 2017;42(4):388-399.e3. doi:10.1016/j.devcel.2017.07.022

7. Liu JX, Thornell LE, Pedrosa-Domellöf F. Muscle spindles in the deep muscles of the human neck: A morphological and immunocytochemical study. *J Histochem Cytochem*. 2003;51(2):175-186. doi:10.1177/002215540305100206

8. Adler SS, Beckers D, Buck M. PNF in Practice: an Illustrated Guide ,4. 2019;4(2):1-7.

9. O'Sullivan S, Schmitz T. *Improving Functional Outcomes in Rehabilitation*. Vol 91.; 2010.

10. Stillman BC. Making sense of proprioception: The meaning of proprioception, kinaesthesia and related terms. *Physiotherapy*. 2002;88(11):667-676. doi:10.1016/S0031-9406(05)60109-5

11. Michael-Titus A, Revest P, Shortland P. THE SPINAL CORD. In: *The Nervous System*. Churchill Livingstone; 2010:59-78. doi:10.1016/B978-0-7020-3373-

5.00004-6

12. Röijezon U, Clark NC, Treleaven J. Proprioception in musculoskeletal rehabilitation. Part 1: Basic science and principles of assessment and clinical interventions. *Man Ther*. 2015;20(3):368-377. doi:10.1016/j.math.2015.01.008

13. Bear MF, Connors BW, Paradiso MA. *Neuroscience : Exploring the Brain*. Lippincott Williams & Wilkins; 2007.

14. Hindle K, Whitcomb T, Briggs W, Hong J. Proprioceptive Neuromuscular Facilitation (PNF): Its Mechanisms and Effects on Range of Motion and Muscular Function. *J Hum Kinet*. 2012;31(1):105-113. doi:10.2478/v10078-012-0011-y

15. Latash ML. *Neurophysiological Structures*.; 2012. doi:10.1016/b978-0-12-415956-3.00010-5

16. Treleaven J. Sensorimotor disturbances in neck disorders affecting postural stability, head and eye movement control-Part 2: Case studies. *Man Ther*. 2008;13(3):266-275. doi:10.1016/j.math.2007.11.002

17. Uthaikhup S, Jull G, Sungkarat S, Treleaven J. The influence of neck pain on sensorimotor function in the elderly. *Arch Gerontol Geriatr*. 2012;55(3):667-672. doi:10.1016/j.archger.2012.01.013

18. Olyaei GR, Maroufi N, Mousavi-Khatir R, Toosizadeh N, Talebian S. Disturbance of neck proprioception and feed-forward motor control following static neck flexion in healthy young adults. *J Electromyogr Kinesiol*. 2018;41:160-167. doi:10.1016/j.jelekin.2018.04.013

19. de Vries J, Ischebeck BK, Voogt LP, et al. Joint position sense error in people with neck pain: A systematic review. *Man Ther*. 2015;20(6):736-744. doi:10.1016/j.math.2015.04.015

20. Hong BY, Ko YJ, Cho YR, et al. Effects of joint effusion on proprioception in patients with knee osteoarthritis: a single-blind, randomized controlled clinical trial. *Osteoarthr Cartil*. 2010;19(1):22-28. doi:10.1016/j.joca.2010.10.013

21. Willems T, Witvrouw E, Verstuyft J, Vaes P, De Clercq D. Proprioception and

Muscle Strength in Subjects With a History of Ankle Sprains and Chronic Instability. *J Athl Train*. 2002;37(4):487-493. doi:10.4085/1062-6050-44.6.617

22. Allen TJ, Leung M, Proske U. The effect of fatigue from exercise on human limb position sense. *J Physiol*. 2010;588(8):1369-1377. doi:10.1113/jphysiol.2010.187732

23. Hughes CML, Tommasino P, Budhota A, Campolo D. Upper Extremity Proprioception in Healthy Aging and Stroke Populations, and the Effects of Therapist- and Robot-Based Rehabilitation Therapies on Proprioceptive Function. *Front Hum Neurosci*. 2015;9(March):1-11. doi:10.3389/fnhum.2015.00120

24. Goble DJ, Coxon JP, Van Impe A, et al. The neural basis of central proprioceptive processing in older versus younger adults: An important sensory role for right putamen. *Hum Brain Mapp*. 2012;33(4):895-908. doi:10.1002/hbm.21257

25. Meyer S, Feys H, Thijs V, Karttunen AH, Verheyden G. How Do Somatosensory Deficits in the Arm and Hand Relate to Upper Limb Impairment, Activity, and Participation Problems After Stroke? A Systematic Review. *Phys Ther*. 2014;94(9):1220-1231. doi:10.2522/ptj.20130271

26. Zia S, Cody F, O’Boyle D. Joint position sense is impaired by Parkinson’s disease. *Ann Neurol*.2000;47(2):218-228.doi:10.1002/1531-8249

27. Bove M, Brichetto G, Abbruzzese G, Marchese R, Schieppati M. Neck proprioception and spatial orientation in cervical dystonia. *Brain*. 2004;127(12):2764-2778. doi:10.1093/brain/awh291

28. Abbruzzese G, Trompetto C, Mori L, Pelosin E. Proprioceptive Rehabilitation of Upper Limb Dysfunction in Movement Disorders: A Clinical Perspective. *Front Hum Neurosci*. 2014;8(November):1-8. doi:10.3389/fnhum.2014.00961

29. Park Y-H, Kim Y, Lee B-H. An Ankle Proprioceptive Control Program Improves Balance, Gait Ability of Chronic Stroke Patients. *J Phys Ther Sci*. 2013;25(10):1321-1324. doi:10.1589/jpts.25.1321

30. Kim SI, Song IH, Cho S, et al. Proprioception rehabilitation training system for

stroke patients using virtual reality technology. *Proc Annu Int Conf IEEE Eng Med Biol Soc EMBS*. 2013:4621-4624. doi:10.1109/EMBC.2013.6610577

31. Kiper P, Baba A, Agostini M, Turolla A. Proprioceptive Based Training for stroke recovery. Proposal of new treatment modality for rehabilitation of upper limb in neurological diseases. *Arch Physiother*. 2015;5(1):1-6. doi:10.1186/s40945-015-0007-8

32. Aman JE, Elangovan N, Yeh I-L, Konczak J. The effectiveness of proprioceptive training for improving motor function: a systematic review. *Front Hum Neurosci*. 2015;8(January):1-18. doi:10.3389/fnhum.2014.01075

33. Clark NC, Röijezon U, Treleaven J. Proprioception in musculoskeletal rehabilitation. Part 2: Clinical assessment and intervention. *Man Ther*. 2015;20(3):378-387. doi:10.1016/j.math.2015.01.009

34. Malmström EM, Fransson PA, Jaxmar Bruinen T, Facic S, Tjernström F. Disturbed cervical proprioception affects perception of spatial orientation while in motion. *Exp Brain Res*. 2017;235(9):2755-2766. doi:10.1007/s00221-017-4993-5

35. Beinert K, Preiss S, Huber M, Taube W. Cervical joint position sense in neck pain. Immediate effects of muscle vibration versus mental training interventions: a RCT. *Eur J Phys Rehabil Med*. 2015;51(6):825-832. doi:51(6):825-32

36. Hidalgo-Peréz A, Fernández-García Á, López-de-Uralde-Villanueva I, et al. EFFECTIVENESS OF A MOTOR CONTROL THERAPEUTIC EXERCISE PROGRAM COMBINED WITH MOTOR IMAGERY ON THE SENSORIMOTOR FUNCTION OF THE CERVICAL SPINE: A RANDOMIZED CONTROLLED TRIAL. *Int J Sports Phys Ther*. 2015;10(6):877-892.

37. Gunning E, Uszynski MK. Effectiveness of the Proprioceptive Neuromuscular Facilitation Method on Gait Parameters in Patients With Stroke: A Systematic Review. *Archives of Physical Medicine and Rehabilitation*. https://doi.org/10.1016/j.apmr.2018.11.020. Published 2019.

38. Areeudomwong P, Buttagat V. Proprioceptive neuromuscular facilitation training

improves pain-related and balance outcomes in working-age patients with chronic low back pain: a randomized controlled trial. *Brazilian Journal of Physical Therapy*. 2018.

39. Machado D de CD, Bastos VH do V, Santos AP, Neves CDC, Pereira PD, Gontijo LB. Evaluation of Strength and Irradiated Movement Pattern Resulting from Trunk Motions of the Proprioceptive Neuromuscular Facilitation. *Rehabil Res Pract*. 2012;2012:1-6. doi:10.1155/2012/281937

40. Abreu R, Lopes AA, Sousa ASP, Pereira S, Castro MP. Force irradiation effects during upper limb diagonal exercises on contralateral muscle activation. *J Electromyogr Kinesiol*. 2015;25(2):292-297. doi:10.1016/j.jelekin.2014.12.004

41. Chalmers G. Strength training: Re- examination of the possible role of golgi tendon organ and muscle spindle reflexes in proprioceptive neuromuscular facilitation muscle stretching. *Sport Biomech*. 2004;3(1):159-183. doi:10.1080/14763140408522836

42. Chaturvedi P, Kumar Singh A, Kulshreshtha D, Kumar Thacker A. PNF in acute stroke. *MOJ Anat Physiol*. 2018;5(6):391-399. doi:10.15406/mojap.2018.05.00232

43. Heckman CJ, Enoka RM. Motor unit. *Compr Physiol*. 2012;2(4):2629-2682. doi:10.1002/cphy.c100087

44. Gabriel DA, Kamen G, Frost G. Neural adaptations to resistive exercise: Mechanisms and recommendations for training practices. *Sport Med*. 2006;36(2):133-149. doi:10.2165/00007256-200636020-00004

45. Murphy SA, Berrios R, Nelson PA, et al. Impaired regulation post-stroke of motor unit firing behavior during volitional relaxation of knee extensor torque assessed using high density surface EMG decomposition. In: *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*. Vol 2015-Novem. IEEE; 2015:4606-4609. doi:10.1109/EMBC.2015.7319420

46. McPherson LM, Negro F, Thompson CK, et al. Properties of the motor unit action

potential shape in proximal and distal muscles of the upper limb in healthy and post-stroke individuals. In: *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*. Vol 2016-Octob. IEEE; 2016:335-339. doi:10.1109/EMBC.2016.7590708

47. Schmit BD, Hunter SK, Onushko T, et al. Stroke increases ischemia-related decreases in motor unit discharge rates. *J Neurophysiol*. 2018;120(6):3246-3256. doi:10.1152/jn.00923.2017

48. Nijs J, Daenen L, Cras P, Struyf F, Roussel N, Oostendorp RAB. Nociception affects motor output: A review on sensory-motor interaction with focus on clinical implications. *Clin J Pain*. 2012;28(2):175-181. doi:10.1097/AJP.0b013e318225daf3

49. Wan JJ, Qin Z, Wang PY, Sun Y, Liu X. Muscle fatigue: General understanding and treatment. *Exp Mol Med*. 2017;49(10):e384-11. doi:10.1038/emm.2017.194

50. Tieland M, Trouwborst I, Clark BC. Skeletal muscle performance and ageing. *J Cachexia Sarcopenia Muscle*. 2018;9(1):3-19. doi:10.1002/jcsm.12238

51. Yang CC, Su FC, Yang PC, Lin HT, Guo LY. Characteristics of the motor units during sternocleidomastoid isometric flexion among patients with mechanical neck disorder and asymptomatic individuals. *PLoS One*. 2016;11(12):1-14. doi:10.1371/journal.pone.0167737

52. De Luca CJ, Gonzalez-Cueto JA, Bonato P, Adam A. Motor Unit Recruitment and Proprioceptive Feedback Decrease the Common Drive. *J Neurophysiol*. 2008;101(3):1620-1628. doi:10.1152/jn.90245.2008

53. De Luca CJ, Kline JC. Influence of proprioceptive feedback on the firing rate and recruitment of motoneurons. *J Neural Eng*. 2012;9(1):016007. doi:10.1088/1741-2560/9/1/016007

54. Coertjens M, Bastos VH, Teles Monteiro MG, et al. Diagonal movement of the upper limb produces greater adaptive plasticity than sagittal plane flexion in the shoulder. *Neurosci Lett*. 2017;643:8-15. doi:10.1016/j.neulet.2017.02.022

55. Lial L, Moreira R, Correia L, et al. Proprioceptive neuromuscular facilitation increases alpha absolute power in the dorsolateral prefrontal cortex and superior parietal cortex. *Somatosens Mot Res*. 2017;34(3):204-212. doi:10.1080/08990220.2017.1392298

56. C. Fuzaro A, Ferreira ACS, C. Meningroni P, et al. Ipsilateral proprioceptive neuromuscular facilitation patterns improve overflow and reduce foot drop in patients with demyelinating polyneuropathy. *J Exerc Rehabil*. 2018;14(3):503-508. doi:10.12965/jer.1836178.089

57. Minshull C, Eston R, Bailey A, Rees D, Gleeson N. The differential effects of PNF versus passive stretch conditioning on neuromuscular performance. *Eur J Sport Sci*. 2014;14(3):233-241. doi:10.1080/17461391.2013.799716

58. El-Tamawy M, Darwish M, Khallaf M. Effects of augmented proprioceptive cues on the parameters of gait of individuals with Parkinson′s disease. *Ann Indian Acad Neurol*. 2012;15(4):267. doi:10.4103/0972-2327.104334

59. Surburg PR, Schrader JW. Proprioceptive Neuromuscular Facilitation Techniques. *J Athl Train*. 1997;32(1):34-39.

60. Youdas JW, Arend DB, Exstrom JM, J.helmus T, Rozeboom JD, Hollman JH. Comparison of muscle activation levels during arm abduction in the plane of the scapula vs. proprioceptive neuromuscular facilitation upper extremity patterns. *J Strength Cond Res*. 2012;26(4):1058-1065. doi:10.1519/JSC.0b013e31822e597f

61. Lee C-W, Hwangbo K, Lee I-S. The Effects of Combination Patterns of Proprioceptive Neuromuscular Facilitation and Ball Exercise on Pain and Muscle Activity of Chronic Low Back Pain Patients. *J Phys Ther Sci*. 2014;26(1):93-96. doi:10.1589/jpts.26.93

62. Areeudomwong P, Wongrat W, Neammesri N, Thongsakul T. A randomized controlled trial on the long-term effects of proprioceptive neuromuscular facilitation training, on pain-related outcomes and back muscle activity, in patients with chronic low back pain. *Musculoskeletal Care*. 2017;15(3):218-229. doi:10.1002/msc.1165

63. Maicki T, Bilski J, Szczygiel E, Trąbka R. PNF and manual therapy treatment results of patients with cervical spine osteoarthritis. *J Back Musculoskelet Rehabil*. 2017;30(5):1095-1101. doi:10.3233/BMR-169718

64. Hwangbo PN, Don Kim K. Effects of proprioceptive neuromuscular facilitation neck pattern exercise on the ability to control the trunk and maintain balance in chronic stroke patients. *J Phys Ther Sci*. 2016;28(3):850-853. doi:10.1589/jpts.28.850

65. Sharman MJ, Cresswell AG, Riek S. Facilitation stretching mechanisms and clinical implications. *Sports Med*. 2006;36(11):929-939.

66. Ryan EE, Rossi MD, Lopez R. The effects of the contract-relax-antagonist-contract form of proprioceptive neuromuscular facilitation stretching on postural stability. *J Strength Cond Res*. 2010;24(7):1888-1894. doi:10.1519/JSC.0b013e3181ddad9d

67. Yavuz UŞ, Negro F, Diedrichs R, Farina D. Reciprocal inhibition between motor neurons of the tibialis anterior and triceps surae in humans. *J Neurophysiol*. 2018:1699-1706. doi:10.1152/jn.00424.2017

68. Behm DG, Blazevich AJ, Kay AD, McHugh M. Acute effects of muscle stretching on physical performance, range of motion, and injury incidence in healthy active individuals: a systematic review. *Appl Physiol Nutr Metab*. 2015;41(1):1-11. doi:10.1139/apnm-2015-0235

69. Lempke L, Wilkinson R, Murray C, Stanek J. The Effectiveness of PNF Versus Static Stretching on Increasing Hip-Flexion Range of Motion. *J Sport Rehabil*. 2017;27(3):289-294. doi:10.1123/jsr.2016-0098

70. Akbulut T, Agopyan A. Effects of an Eight-Week Proprioceptive Neuromuscular Facilitation Stretching Program on Kicking Speed and Range of Motion in Young Male Soccer Players. *J Strength Cond Res*. 2015;29(12):3412-3423. doi:10.1519/JSC.0000000000001015

71. Kay AD, Dods S, Blazevich AJ. Acute effects of contract–relax (CR) stretch versus a modified CR technique. *Eur J Appl Physiol*. 2016;116(3):611-621.

doi:10.1007/s00421-015-3320-8

72. Medeiros DM, Martini TF. Chronic effect of different types of stretching on ankle dorsiflexion range of motion: Systematic review and meta-analysis. *Foot*. 2018;34:28-35. doi:10.1016/j.foot.2017.09.006

73. Lazarou L, Kofotolis N, Pafis G, Kellis E. Effects of two proprioceptive training programs on ankle range of motion, pain, functional and balance performance in individuals with ankle sprain. *J Back Musculoskelet Rehabil*. 2018;31(3):437-446. doi:10.3233/BMR-170836

74. Borges MO, Medeiros DM, Minotto BB, Lima CS. Comparison between static stretching and proprioceptive neuromuscular facilitation on hamstring flexibility: systematic review and meta-analysis. *Eur J Physiother*. 2018;20(1):12-19. doi:10.1080/21679169.2017.1347708

75. Cayco CS, Labro A V, Gorgon EJR. Hold-relax and contract-relax stretching for hamstrings flexibility: A systematic review with meta-analysis. *Phys Ther Sport*. 2019;35:42-55. doi:10.1016/j.ptsp.2018.11.001

76. Schuback B, Hooper J, Salisbury L. A comparison of a self-stretch incorporating proprioceptive neuromuscular facilitation components and a therapist-applied PNF-technique on hamstring flexibility. *Physiotherapy*. 2004;90(3):151-157. doi:10.1016/j.physio.2004.02.009

77. Khodayari B, Dehghani Y. The Investigation of Mid-term Effect of Different Intensity of PNF Stretching on Improve Hamstring Flexibility. *Procedia - Soc Behav Sci*. 2012;46:5741-5744. doi:10.1016/j.sbspro.2012.06.508

78. O'Hora J, Cartwright A, Wade CD, Hough AD, Shum GLK. Efficacy of static stretching and proprioceptive neuromuscular facilitation stretch on hamstrings length after a single session. *J Strength Cond Res*. 2011;25(6):1586-1591. doi:10.1519/JSC.0b013e3181df7f98

79. Magalhães FEX, Rodrigues EC, Gouveia GP de M, et al. Comparison of the effects of hamstring stretching using proprioceptive neuromuscular facilitation with prior application of cryotherapy or ultrasound therapy. *J Phys Ther Sci*.

2015;27(5):1549-1553. doi:10.1589/jpts.27.1549

80. Szafraniec R, Chromik K, Poborska A, Kawczyński A. Acute effects of contract-relax proprioceptive neuromuscular facilitation stretching of hip abductors and adductors on dynamic balance. *PeerJ*. 2018;6:e6108. doi:10.7717/peerj.6108

81. Younis Aslan HI, Buddhadev HH, Suprak DN, San Juan JG. ACUTE EFFECTS OF TWO HIP FLEXOR STRETCHING TECHNIQUES ON KNEE JOINT POSITION SENSE AND BALANCE. *Int J Sports Phys Ther*. 2018;13(5):846-859. doi:10.26603/ijspt20180846

82. Espí-López G V., López-Martínez S, Inglés M, Serra-Añó P, Aguilar-Rodríguez M. Effect of manual therapy versus proprioceptive neuromuscular facilitation in dynamic balance, mobility and flexibility in field hockey players. A randomized controlled trial. *Phys Ther Sport*. 2018;32:173-179. doi:10.1016/j.ptsp.2018.04.017

83. Yuktasir B, Kaya F. Investigation into the long-term effects of static and PNF stretching exercises on range of motion and jump performance. *J Bodyw Mov Ther*. 2009;13(1):11-21. doi:10.1016/j.jbmt.2007.10.001

84. Young W, Elliott S. Acute Effects of Static Stretching, Proprioceptive Neuromuscular Facilitation Stretching, and Maximum Voluntary Contractions on Explosive Force Production and Jumping Performance. *Res Q Exerc Sport*. 2001;72(3):273-279. doi:10.1080/02701367.2001.10608960

85. Hillier S, Immink M, Thewlis D. Assessing Proprioception. *Neurorehabil Neural Repair*. 2015;29(10):933-949. doi:10.1177/1545968315573055

86. Adams R, Han J, Liu Y, Anson J, Waddington G. Assessing proprioception: A critical review of methods. *J Sport Heal Sci*. 2015;5(1):80-90. doi:10.1016/j.jshs.2014.10.004

87. Benjaminse A, Sell TC, Abt JP, House AJ, Lephart SM. Reliability and precision of hip proprioception methods in healthy individuals. *Clin J Sport Med*. 2009;19(6):457-463. doi:10.1097/JSM.0b013e3181bcb155

88. Down S, Waddington G, Adams R, Thomson M. Movement discrimination after intra-articular local anaesthetic of the ankle joint. *Br J Sports Med*. 2007;41(8):501-505. doi:10.1136/bjsm.2006.031468

89. Stillman BC. An investigation of the clinical assessment of joint position sense. PhD Thesis, School of Physiotherapy. May 2000. http://hdl.handle.net/11343/38786.

90. Strimpakos N. The assessment of the cervical spine. Part 1: Range of motion and proprioception. *J Bodyw Mov Ther*. 2011;15(1):114-124. doi:10.1016/j.jbmt.2009.06.003

91. Jull G, Falla D, Treleaven J, Hodges P, Vicenzino B. Retraining cervical joint position sense: The effect of two exercise regimes. *J Orthop Res*. 2007;25(3):404-412. doi:10.1002/jor.20220

92. Gallego Izquierdo T, Pecos-Martin D, Lluch Girbés E, et al. Comparison of cranio-cervical flexion training versus cervical proprioception training in patients with chronic neck pain: A randomized controlled clinical trial. *J Rehabil Med*. 2016;48(1):48-55. doi:10.2340/16501977-2034

93. Beinert K, Keller M, Taube W. Neck muscle vibration can improve sensorimotor function in patients with neck pain. *Spine J*. 2015;15(3):514-521. doi:10.1016/j.spinee.2014.10.013

94. Morley J, Sikorski DM. Effect of whole body vibration on cervical (neck) proprioception in young, healthy individuals serving as their own control: a pilot study. *J Can Chiropr Assoc*. 2018;62(1):42-55.

95. Kato S, Takeshita K, Matsudaira K, Tonosu J, Hara N, Chikuda H. Normative score and cut-off value of the neck disability index. *J Orthop Sci*. 2012;17(6):687-693. doi:10.1007/s00776-012-0276-y

96. Oe S, Togawa D, Yoshida G, et al. Cut-off values of and factors associated with a negative influence on Neck Disability Index. *Eur Spine J*. 2018;27(6):1423-1431. doi:10.1007/s00586-018-5555-7

97. Wibault J, Vaillant J, Vuillerme N, Dedering Å, Peolsson A. Using the cervical range of motion (CROM) device to assess head repositioning accuracy in individuals with cervical radiculopathy in comparison to neck- healthy individuals. *Man Ther*. 2013;18(5):403-409. doi:10.1016/j.math.2013.02.004

98. Burke S, Lynch K, Moghul Z, Young C, Saviola K, Schenk R. The reliability of the cervical relocation test on people with and without a history of neck pain. *J Man Manip Ther*. 2016:1-5. doi:10.1179/2042618615Y.0000000016

99. Reddy R, Alahmari K. Cervical proprioception evaluation using cervical range of motion device: A narrative review. *Saudi J Sport Med*. 2015;15(2):127. doi:10.4103/1319-6308.156342

100. Audette I, Dumas J-P, Côté JN, De Serres SJ. Validity and Between-Day Reliability of the Cervical Range of Motion (CROM) Device. *J Orthop Sport Phys Ther*. 2010;40(5):318-323. doi:10.2519/jospt.2010.3180

101. Rheault W, Albright B, Byers C, et al. Intertester Reliability of the Cervical Range of Motion Device. *J Orthop Sport Phys Ther*. 2013;15(3):147-150. doi:10.2519/jospt.1992.15.3.147

102. Malmström E-M, Karlberg M, Fransson PA, Melander A, Magnusson M. Primary and coupled cervical movements: the effect of age, gender, and body mass index. A 3-dimensional movement analysis of a population without symptoms of neck disorders. *Spine (Phila Pa 1976)*. 2006;31(2):E44-50. http://www.ncbi.nlm.nih.gov/pubmed/16418624. Accessed June 13, 2019.

103. Lansade C, Laporte S, Thoreux P, Rousseau M-A, Skalli W, Lavaste F. Three-Dimensional Analysis of the Cervical Spine Kinematics. *Spine (Phila Pa 1976)*. 2009;34(26):2900-2906. doi:10.1097/brs.0b013e3181b4f667

104. Streepey JW, Mock MJ, Riskowski JL, Vanwye WR, Vitvitskiy BM, Mikesky AE. Effects of quadriceps and hamstrings proprioceptive neuromuscular facilitation stretching on knee movement sensation. *J Strength Cond Res*. 2010;24(4):1037-1042. doi:10.1519/JSC.0b013e3181d09e87

105. Takasaki H, Okubo Y, Okuyama S. The Effect of Proprioceptive Neuromuscular

Facilitation on Joint Position Sense: A Systematic Review. *J Sport Rehabil*. May 2019:1-30. doi:10.1123/jsr.2018-0498

106. Mitchell UH, Myrer JW, Hopkins JT, Hunter I, Feland JB, Hilton SC. Neurophysiological reflex mechanisms' lack of contribution to the success of PNF stretches. *J Sport Rehabil*. 2009;18(3):343-357.

107. Wanderley D, Lemos A, Moretti E, Barros MMMB, Valença MM, de Oliveira DA. Efficacy of proprioceptive neuromuscular facilitation compared to other stretching modalities in range of motion gain in young healthy adults: A systematic review. *Physiother Theory Pract*. 2019;35(2):109-129. doi:10.1080/09593985.2018.1440677

108. Reis E da FS, Pereira GB, de Sousa NMF, et al. Acute effects of proprioceptive neuromuscular facilitation and static stretching on maximal voluntary contraction and muscle electromyographical activity in indoor soccer players. *Clin Physiol Funct Imaging*. 2013;33(6):n/a-n/a. doi:10.1111/cpf.12047

109. Konrad A, Stafilidis S, Tilp M. Effects of acute static, ballistic, and PNF stretching exercise on the muscle and tendon tissue properties. *Scand J Med Sci Sports*. 2017;27(10):1070-1080. doi:10.1111/sms.12725

110. Ralston GW, Kilgore L, Wyatt FB, Baker JS. The Effect of Weekly Set Volume on Strength Gain: A Meta-Analysis. *Sport Med*. 2017;47(12):2585-2601. doi:10.1007/s40279-017-0762-7

APPENDIXES

Appendix 1. Ethical Committee Approval.

T.C. YEDİTEPE ÜNİVERSİTESİ

Sayı : 37068608-6100-15- 1678 **30/05/2019**
Konu: Klinik Araştırmalar
Etik kurul Başvurusu hk.

İlgili Makama (Muhammad Al-Jallad)

Yeditepe Üniversitesi Sağlık Bilimleri Fakültesi Fizyoterapi ve Rehabilitasyon Bölümü. Yard. Doç.Dr.Feyza Şule Badıllı Demirbaş'in sorumlu araştırmacı olduğu **"Servikal Propriosepsiyonda Propriyoseptif Nöromüsküler Kolaylığın Akut Etkisi, Hareket Açıklığı Ve Kuvvet"** isimli araştırma projesine ait Klinik Araştırmalar Etik Kurulu (KAEK) Başvuru Dosyası **(1656) kayıt Numaralı** KAEK Başvuru Dosyası), Yeditepe Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından **29.05.2019** tarihli toplantıda incelenmiştir.

Kurul tarafından yapılan inceleme sonucu, yukarıdaki isimi belirtilen çalışmanın yapılmasının etik ve bilimsel açıdan uygun olduğuna karar verilmiştir (**KAEK Karar No: 1028**).

Prof. Dr. Turgay ÇELİK
Yeditepe Üniversitesi
Klinik Araştırmalar Etik Kurulu Başkanı

Yeditepe Üniversitesi 26 Ağustos Yerleşimi, İnönü Mahallesi Kayışdağı Caddesi 34755 Ataşehir / İstanbul
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Appendix 2. Consent to Participate in a Research Form. (English)

YEDİTEPE ÜNİVERSİTESİ

Consent to Participate in a Research

Title of Study:	The Acute Influence of Proprioceptive Neuromuscular Facilitation on Cervical Proprioception, Range of Motion and Strength.
Investigator:	

Name:	Mohammad Al-Jallad	**Dept:**	Physiotherapy and Rehabilitation	**Phone:**	05050524725

Introduction

- You are being asked to be in a research study of a treatment approach in physiotherapy practice. This approach is widely used in many areas however it is not widely used for neck region therefore this study will test this approach on three aspects joint position sense, range of motion and muscle strength.
- We ask that you read this form and ask any questions that you may have before agreeing to be in the study.

Purpose of Study

- The purpose of the study is to investigate the effects of two approaches of the same treatment technique on neck Proprioception (joint position sense), range of motion and strength of muscles around the neck.
- Ultimately, this research will be used for Master degree thesis and may be used in external publications.

Description of the Study Procedures

- If you agree to be in this study, you will be asked to do the following things:
  1. First an assessor will see you to assess 1. Neck joint position sense 2. Neck ROM using a specific instrument 3. Neck muscles strength using a device.
  2. For intervention part a physiotherapist will ask you to sit on a chair or lay on a treatment table to apply the treatment approach which will only involve your neck and upper body.
  3. We will take the assessment 2 times first before intervention second immediately after intervention.
  4. Assessment might take from 10 to 20 minutes.
  5. Treatment might take from 10-20 minutes.

  Note: Assessment and intervention will involve direct physical contact, if you are uncomfortable with this please inform the investigator before signing this document.

Risks/Discomforts of Being in this Study

- There are no reasonably foreseeable (or expected) risks. There may be unknown risks.
- Due to the nature of the approach that works on muscles a slight discomfort might occur.

Confidentiality

- This study is anonymous. We will not be collecting or retaining any information about your identity.
- The records of this study will be kept strictly confidential. Research records will be kept in a locked file, and all electronic information will be coded and secured using a password protected file. We will not include any information in any report we may publish that would make it possible to identify you.

Right to Refuse or Withdraw

- The decision to participate in this study is entirely up to you. You may refuse to take part in the study *at any time* without affecting your relationship with the investigators of this study or the institution. You have the right not to answer any single question, as well as to withdraw completely from the interview at any point during the process; additionally, you have the right to request that the interviewer not use any of your interview material.

Right to Ask Questions and Report Concerns

- You have the right to ask questions about this research study and to have those questions answered by the investigator before, during or after the research. If you have any further questions about the study, at any time feel free to contact me, [*mohammad aljallad*] at [*mohamed.jallad.pt@gmail.com*] or by telephone at [05050524725]. If you like, a summary of the results of the study will be sent to you. If you have any problems or concerns that occur as a result of your participation, you can report them to the investigator at the number above.

Consent

- Your signature below indicates that you have decided to volunteer as a research participant for this study, and that you have read and understood the information provided above. You will be given a signed and dated copy of this form to keep, along with any other printed materials deemed necessary by the study investigators.

Participant Name: ______________________________

Participant's Signature: ______________________________ Date: __________________

Researcher Name: Mohammad Al-Jallad

Researcher's Signature: ______________________________ Date: __________________

Assessor Name: Çiçek Duman

Assessor's Signature: ______________________________ Date: __________________

Appendix 2. Consent to Participate in A Research Form. (Turkish)

YEDİTEPE ÜNİVERSİTESİ

Katılımcı Onam Formu

Çalışmanın Adı:	Proprioseptif Nöromuskular Fasilitasyonun Servikal Bölge Propriosepsiyonu, Eklem Hareket Açıklığı ve Kas Kuvveti Üzerine Etkisi

Araştırmacının:

Adı:	Mohammad Al-Jallad	**Bölümü:**	Fizyoterapi ve Rehabilitasyon	**Telefon:**	05050524725

Giriş

- Sizden, fizyoterapi ve rehabilitasyon alanında kullanılmakta olan bir tedavi yaklaşımının araştırma çalışmasında bulunmanız istenmektedir. Bu yaklaşım sıklıkla uygulansa da boyun bölgesinde yaygın olarak kullanılmamaktadır. Bu nedenle katılmakta olduğunuz çalışma, bu yaklaşımı eklem pozisyonu algısı, hareket açıklığı ve kas kuvveti olmak üzere üç açıdan araştırmaktadır.
- Bu formu okumanızı ve araştırmaya katılmayı kabul etmeden önce, aklınıza gelebilecek tüm soruları sormanız beklenmektedir.

Çalışmanın Amacı

- Bu çalışmanın amacı aynı tedavi tekniğinin iki farklı yaklaşımının boyun propriyosepsiyonu (eklem pozisyonu duyusu), eklem hareket açıklığı ve boyun çevresindeki kasların gücü üzerine etkilerini araştırmaktır.
- Bu çalışmanın çıktıları, yüksek lisans tezi için kullanılacaktır ve sonuçlar, çeşitli yayınlarda kullanılabilir.

Çalışma Prosedürlerinin Açıklaması

- Çalışmaya katılmayı kabul etmeniz konumunda aşağıdakileri yapmanız istenecektir:
  6. İlk olarak bir değerlendirici ölçümler için özel üretilmiş cihazlar kullanarak sizi a. boyun eklemi pozisyon duyusu b. boyun eklemi hareket miktarı c. boyun kasları gücü açısından değerlendirecektir
  7. Çalışmanın uygulama yapılacak bölümünde bir fizyoterapist sizden, yalnızca boynunuzu ve üst bedeninizi içeren tedavi yaklaşımını uygulamak için bir sandalyeye oturmanızı veya bir tedavi masasına yatmanızı isteyecektir.
  8. Değerlendirmeler müdahaleden hemen sonra ikinci kere tekrarlanacaktır.
  9. Değerlendirme 10 ila 20 dakika sürebilir.
  10. Uygulama 10-20 dakika kadar sürebilir

  Not: Yapılacak olan değerlendirme ve uygulama fiziksel temas gerektirmektedir. Bu nedenle rahatsızlık hissedeceğinizi düşünüyorsanız lütfen değerlendiriciyi bu belgeyi imzalamadan önce bilgilendiriniz.

Olası Riskler/Rahatsızlıklar

- Çalışma öngörülebilir (veya beklenen) riskler içermemektedir. Bilinmeyen riskler olabilir.

- Kaslarda, uygulanan yaklaşımın doğası gereği hafif bir rahatsızlık hissi meydana gelebilir.

Gizlilik

- Bu çalışma anonimdir. Kimliğiniz hakkında herhangi bir bilgi toplanmayacak veya kullanım amaçlı saklanmayacaktır.
- Bu çalışmanın kayıtları kesinlikle gizli tutulacaktır. Araştırma kayıtları kilitli bir dosyada tutulacak ve tüm elektronik bilgiler şifre korumalı bir dosya kullanılarak güvence altına alınacaktır. Yayınlanabilecek hiçbir rapora, sizi tanımlamayı mümkün kılacak hiçbir bilgi dahil edilmeyecektir.

Reddetme veya Çekilme Hakkı

- Bu çalışmaya katılma kararı tamamen size bağlıdır. Bu araştırmanın ya da kurumun araştırmacılarıyla ilişkinizi etkilemeden, herhangi bir zamanda çalışmaya katılmayı reddedebilirsiniz. Herhangi bir soruya cevap vermeme, işlem sırasında herhangi bir noktada görüşmeden tamamen geri çekilme veya görüşmeci tarafından görüşme materyallerinizi kullanmasını istememe hakkına sahipsiniz.

Soru Sorma ve Endişelerini Rapor Etme Hakkı

- Bu araştırma çalışması hakkında soru sorma ve bu soruların araştırma öncesi, sırası veya sonrasında araştırmacı tarafından yanıtlanması hakkına sahipsiniz. Çalışma hakkında herhangi bir sorunuz olursa, istediğiniz zaman [mohamed.jallad.pt@gmail.com] adresinden veya [05050524725] numaralı telefondan iletişime geçmekten çekinmeyin. İsterseniz, çalışmanın sonuçlarının bir özeti size gönderilecektir. Katılımınızın sonucu olarak ortaya çıkan herhangi bir sorun veya endişeniz varsa, bunları yukarıdaki numaradan araştırmacıya bildirebilirsiniz.

Onam

- Aşağıdaki imzanız, bu çalışma için bir araştırma katılımcısı olarak gönüllü olmaya karar verdiğinizi ve yukarıda verilen bilgileri okuyup anladığınızı gösterir. Bu formun imzalı ve tarihli bir kopyası, çalışma araştırmacıları tarafından gerekli görülen diğer basılı materyallerle birlikte saklamanız için size verilecektir.

Katılımcının Adı Soyadı: ______________________________

Katılımcının İmzası: ______________________________ Tarih: __________________

Araştırmacının Adı Soyadı: Mohammad Al-Jallad

İmzası ______________________________ Tarih: __________________

Değerlendiricinin Adı Soyadı: Çiçek Duman

İmzası ______________________________ Tarih: __________________

Appendix 3: Data collection forms

1) Adı-Soyadı: .... Cep Telefon Numarası: ....

2) Doğum Tarihi: ....

3) Cinsiyet:

[ ] Kadın [ ] Erkek

4) Boy Uzunluğu (cm):

5) Vücut Ağırlığı (kg): 6) BMI:

7) Dominant Taraf:

[ ] Sağ [ ] Sol

8) Sigara İçiyor Musunuz?

[ ] Hiç İçmedim [ ] Sigara İçtim Ama Bıraktım [ ] Hala İçiyorum

9) Alkol Kullanıyor Musunuz?

[ ] Hayır [ ] Özel Günlerde [ ] Ayda birkaç kez

[ ] Haftada birkaç kez [ ] Her gün düzenli

10) Herhangi bir sürekli hastalığınız var mı?

[ ] Yok. [ ] Romatizmal [ ] Vestibular [ ] Travmatik

[ ] Ortopedik Problemler [ ] Nörolojik Problemler [ ] Diğer

11) Sürekli kullandığınız bir ilaç var mı?

[ ] Evet (..) [ ] Hayır

12) Herhangi bir ameliyat geçirdiniz mi (sünnet hariç)?

[ ] Evet .... [ ] Hayır

13) Fiziksel aktivite yapıyor musunuz?

[ ] Yapmıyorum. [ ] Haftada 3 günden az [ ] Haftada 3 gün veya daha fazla

14) Egzersizin tipi:

[ ] Yapmıyorum [ ] Fitness [ ] Pilates [ ] Yüzme [ ] Vücut Geliştirme

[ ] Futbol [ ] Koşu [ ] Yürüyüş [ ] Voleybol [ ] Basketbol

15) Egzersizin süresi: ....

16) Fiziksel performans düzeyinizi nasıl algılarsınız/nasıl tanımlarsınız?

[ ] Çok zayıf [ ] Zayıf [ ] Orta [ ] İyi [ ] Çok iyi

1) Name Surname: .... Telephone Number: ....

2) Birthday: ....

3) Gender:

[ ] Female [ ] Male

4) Height (cm):

5) Weight (kg): 6) BMI:

7) Dominant Side:

[ ] Right [ ] Left

8) Smoking habit:

[ ] Never [ ] Quit [ ] Yes

9) Alcohol Consumption Habit:

[ ] Never [ ] Only Special Days [ ] Several times a month

[ ] Few times a week [ ] Regularly everyday

10) Do you have any disease?

[ ] No [ ] Rheumatismal [ ] Vestibular [ ] Traumatic

[ ] Orthopaedic [ ] Neurologic [ ] Different type

11) Is there any medication using regularly?

[ ] Yes .... [ ] No

12) Did you get any surgery (except circumcision)?

[ ] Yes .... [ ] No

13) Exercise habit:

[ ] Never [ ] Less than 3 days [ ] 3 days or more

14) Exercise Type:

[ ] Never [ ] Fitness [ ] Pilates [ ] Swimming [ ] Strength

[ ] Football [ ] Running [ ] Walking [ ] Volleyball [ ] Basketball

15) Duration of the exercise: ....

16) How can you define your performance level?

[ ] Very weak [ ] Weak [ ] Moderate [ ] Good [ ] Very good

Proprioception (PROP)							
		Flex	Ext	RR	LR	RLB	LLB
Before	**1st Trial**						
	2nd Trial						
	3rd Trial						
	Mean						
After	**1st Trial**						
	2nd Trial						
	3rd Trial						
	Mean						

Neck Region Range of Motion (ROM)							
		Flex	Ext	RR	LR	RLB	LLB
Before	**1st Trial**						
	2nd Trial						
	3rd Trial						
	Mean						
After	**1st Trial**						
	2nd Trial						
	3rd Trial						
	Mean						

Neck Region Muscle Strength (STRENGTH)							
		Flex	Ext	RR	LR	RLB	LLB
Before	**1st Trial**						
	2nd Trial						
	3rd Trial						
	Mean						
After	**1st Trial**						
	2nd Trial						
	3rd Trial						
	Mean						

Appendix 4. Turkish version of modified Neck Disability Index

BOYUN ÖZÜRLÜLÜK SORGULAMA FORMU

Bu sorgulama formu boyun ağrınızın günlük yaşam aktivitelerinizi yerine getirme yeteneklerinizi nasıl etkilediğini anlamamıza yardımcı olacak şekilde tasarlanmıştır. Lütfen her bölümdeki bir kutucuğu işaretleyiniz. Bir bölümde birden çok yanıtı kendinize yakın hissetseniz bile, şu anki durumunuza en yakın olan seçeneği işaretleyiniz.

Bölüm 1 - Boyunda Ağrı Yoğunluğu

- Şu anda hiç boyun ağrım yok.
- Şu anda çok hafif derecede boyun ağrım var.
- Boyun ağrım orta derecede ve gelip gidiyor.
- Boyun ağrım orta şiddette ve değişkenlik göstermiyor.
- Boyun ağrım şiddetli fakat gelip gidiyor.
- Boyun ağrım şiddetli ve değişkenlik göstermiyor.

Bölüm 2 - Kişisel Bakım (giyinme ve temizlenme)

- Ek bir ağrıya neden olmadan kendime bakabiliyorum.
- Kendime normal olarak bakabiliyorum fakat bu ek bir ağrıya neden oluyor.
- Kendi bakımımı yaparken ağrım artıyor, yavaşlıyorum ve dikkatli oluyorum.
- Biraz yardıma ihtiyacım var fakat kişisel bakımımın çoğunu yapabiliyorum.
- Kişisel bakımım ile ilgili işlerin çoğunda her gün yardıma ihtiyacım var.
- Giyinemiyorum. Zorlukla yıkanıyorum ve yataktan çıkmıyorum.

Bölüm 3 – Yük Kaldırma (boyun ağrınız olmadığı zamanlarda kaldırdığınız ağır yüklere eşit ağırlıkta)

- Ek bir ağrı hissetmeden ağır yükleri kaldırabiliyorum.
- Ağır yükleri kaldırabiliyorum, fakat ek bir ağrıya neden oluyor.
- Ağrı yükleri yerden kaldırmama engel oluyor, fakat yükler, örneğin masa üstü gibi uygun bir yere yerleştirilirse kaldırabiliyorum.
- Ağrı ağır yük kaldırmama engel oluyor, fakat hafif ve orta ağırlıktaki yükler örneğin masa üstü gibi uygun bir yere yerleştirilirse kaldırabiliyorum.
- Çok hafif yükleri kaldırabiliyorum.
- Hiçbirşeyi kaldıramıyorum ve taşıyamıyorum.

Bölüm 4 - Okuma

- Hiç boyun ağrısı hissetmeden istediğim kadar okuyabiliyorum.
- Hafif bir boyun ağrısı hissederek istediğim kadar okuyabiliyorum.
- Orta derecede boyun ağrısı hissederek istediğim kadar okuyabiliyorum.
- Boynumda orta derecede ağrı nedeniyle istediğim kadar okuyamıyorum.
- Boynumda şiddetli ağrı nedeniyle istediğim kadar okuyamıyorum.
- Boyun ağrısı nedeniyle hiç okuyamıyorum.

Bölüm 5 - Başağrıları

- Hiç başağrım yok.
- Sık olmayan hafif başağrılarım var.
- Orta derecede başağrılarım var.
- Sık gelen orta derecede başağrılarım var
- Sık gelen ağır derecede başağrılarım var.
- Hemen hemen herzaman başağrılarım var.

Bölüm 6 – Konsantrasyon

- İstediğim zaman dikkatimi hiç zorlanmadan istediğim kadar toplayabiliyorum.
- Hafifçe zorlanarak dikkatimi toplayabiliyorum.
- İstediğim zaman biraz zorlanarak dikkatimi toplayabiliyorum.
- İstediğim zaman epeyce zorlanarak dikkatimi toplayabiliyorum.
- İstediğim zaman dikkatimi toplamakta çok fazla zorlanıyorum.
- Dikkatimi hiç toplayamıyorum..

Bölüm-7 İş (Herhangi bir işte çalışmıyorsanız lütfen G seçeneğini işaretleyiniz)

- ediğim kadar iş yapabilirim.
- Her günkü işlerimi yapabilirim, ama daha fazlasını yapamam.
- Her günkü işlerimin çoğunu yapabilirim, daha fazlasını yapamam.
- Her günkü işlerimi yapamam.
- Herhangi bir işi zorlukla yapabilirim.
- Hiçbir iş yapamamG- Hiç yapmadım

Bölüm 8 - Araba Kullanma

- Boyun ağrısı hissetmeden araba kullanabiliyorum.
- Boynumda hafif bir ağrı hissi ile istediğim kadar araba kullanabiliyorum.
- Boynumda orta derecede ağrı nedeni ile istediğim kadar araba kullanamıyorum.
- Orta derecede bir boyun ağrısı nedeniyle istediğim kadar araba kullanamıyorum.
- Boynumda şiddetli ağrı nedeniyle güçlükle araba kullanabiliyorum.
- Boyun ağrısı nedeniyle hiç araba kullanamıyorum.
- Hiç yapmadım

Bölüm 9 - Uyku

- Uyku problemim yok.
- Uykum çok hafif bozuk (bir saatten az süreyle biraz bozuk).
- Uykum hafif bozuk (1-2 saat uykusuzluk).
- Uykum orta derecede bozuk (2-3 saat kadar süren uykusuzluk).
- Uykum çok bozuk (3-5 saat süreyle uykusuzluk).
- Uykum tamamen bozuk (5-7 saat süresince uykusuzluktur).

Bölüm 10 – Boş zaman aktiviteleri

- Tüm boş zaman aktivitelerine boynumda ağrı hissetmeden katılabiliyorum.
- Tüm boş zaman aktivitelerine boynumda biraz ağrı hissederek katılabiliyorum.
- Boynumdaki ağrı nedeni ile tüm boş zaman aktivitelerinin bir kısmına katılabiliyorum.
- Boynumdaki ağrı nedeni ile boş zaman aktivitelerinin çok az bir kısmına katılabiliyorum.
- Boynumdaki ağrı nedeni ile boş zaman aktivitelerine hemen hemen hiç katılamıyorum.
- Hiç bir aktiviteye hiç bir şekilde katılamıyorum.
- Hiç yapmadım

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Hasta Adı ____________Tarih ____________

Neck Disability Index

THIS QUESTIONNAIRE IS DESIGNED TO HELP US BETTER UNDERSTAND HOW YOUR **NECK PAIN** AFFECTS YOUR ABILITY TO MANAGE EVERYDAY -LIFE ACTIVITIES. PLEASE MARK IN EACH SECTION THE **ONE BOX** THAT APPLIES TO YOU.
ALTHOUGH YOU MAY CONSIDER THAT TWO OF THE STATEMENTS IN ANY ONE SECTION RELATE TO YOU, PLEASE MARK THE BOX THAT **MOST CLOSELY** DESCRIBES YOUR PRESENT -DAY SITUATION.

SECTION 1 - PAIN INTENSITY

- ☐ I have no neck pain at the moment.
- ☐ The pain is very mild at the moment.
- ☐ The pain is moderate at the moment.
- ☐ The pain is fairly severe at the moment.
- ☐ The pain is very severe at the moment.
- ☐ The pain is the worst imaginable at the moment.

SECTION 2 - PERSONAL CARE

- ☐ I can look after myself normally without causing extra neck pain.
- ☐ I can look after myself normally, but it causes extra neck 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 causing extra neck pain.
- ☐ I can lift heavy weights, but it gives me extra neck pain.
- ☐ Neck pain prevents me from lifting heavy weights off the floor but I can manage if items are conveniently positioned, ie. on a table.
- ☐ Neck pain prevents me from lifting heavy weights, but I can manage light weights if they are conveniently positioned
- ☐ I can lift only very light weights.
- ☐ I cannot lift or carry anything at all.

SECTION 4 – READING

- ☐ I can read as much as I want with no neck pain.
- ☐ I can read as much as I want with slight neck pain.
- ☐ I can read as much as I want with moderate neck pain.
- ☐ I can't read as much as I want because of moderate neck pain.
- ☐ I can't read as much as I want because of severe neck pain.
- ☐ I can't read at all.

SECTION 5 – HEADACHES

- ☐ I have no headaches at all.
- ☐ I have slight headaches that come infrequently.
- ☐ I have moderate headaches that come infrequently.
- ☐ I have moderate headaches that come frequently.
- ☐ I have severe headaches that come frequently.
- ☐ I have headaches almost all the time.

SECTION 6 – CONCENTRATION

- ☐ I can concentrate fully without difficulty.
- ☐ I can concentrate fully with slight difficulty.
- ☐ I have a fair degree of difficulty concentrating.
- ☐ I have a lot of difficulty concentrating.
- ☐ I have a great deal of difficulty concentrating.
- ☐ I can't concentrate at all.

SECTION 7 – WORK

- ☐ I can do as much work as I want.
- ☐ I can only do my usual work, but no more.
- ☐ I can do most of my usual work, but no more.
- ☐ I can't 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 neck pain.
- ☐ I can drive my car with only slight neck pain.
- ☐ I can drive as long as I want with moderate neck pain.
- ☐ I can't drive as long as I want because of moderate neck pain.
- ☐ I can hardly drive at all because of severe neck pain.
- ☐ I can't drive my care at all because of neck pain.

SECTION 9 – SLEEPING

- ☐ I have no trouble sleeping.
- ☐ My sleep is slightly disturbed for less than 1 hour.
- ☐ My sleep is mildly disturbed for up to 1-2 hours.
- ☐ My sleep is moderately disturbed for up to 2-3 hours.
- ☐ My sleep is greatly disturbed for up to 3-5 hours.
- ☐ My sleep is completely disturbed for up to 5-7 hours.

SECTION 10 – RECREATION

- ☐ I am able to engage in all my recreational activities with no neck pain at all.
- ☐ I am able to engage in all my recreational activities with some neck pain.
- ☐ I am able to engage in most, but not all of my recreational activities because of pain in my neck.
- ☐ I am able to engage in a few of my recreational activities because of neck pain.
- ☐ I can hardly do recreational activities due to neck pain.
- ☐ I can't do any recreational activities due to neck pain.

PATIENT NAME ______________________________ DATE ____________

SCORE ________ [50]

HVERNON@CMCC.CA

Curriculum Vitae

Personal Informations

Name	Mohammad	**Surname**	Al-Jallad
Place of Birth	Amman/Jordan	**Date of Birth**	15/06/1991
Nationality	Jordan	**TR ID Number**	99716820552
E-mail	Mohamed.jallad.pt@gmail.com	**Phone number**	00905050524725

Education

Degree	Department	The name of the Institution Graduated From	Graduation year
Doctorate			
Master			
University	Physiotherapy	**The University of Jordan**	2014
High school	-	**Al-Shaheen private school**	2010

All the grades must be listed if there is more than one (KPDS, ÜDS, TOEFL; EELTS vs),

Languages	Grades (#))
Arabic	Native language
English	

Work Experience (Sort from present to past)

Position	Institute	Duration (Year - Year)
Physiotherapist	Handicap International	2016-2017
Physiotherapist	Al-Essra Hospital	2014-2016

Computer Skills

Program	Level
Microsoft office	Excellent

***Excellent , good, average or basic**

Scientific works

The articles published in the journals indexed by SCI, SSCI, AHCI

Articles published in other journals

Proceedings presented in international scientific meetings and published in proceedings book.

Journals in the proceedings book of the refereed conference / symposium

Others (Projects / Certificates / Rewards)

Clinical orthopedic manual therapy for “Low Back/Pelvis” 16 hours august 2016.
Clinical orthopedic manual therapy for "Neck" 16 Hours, march 2016.
Clinical orthopedic manual therapy for "Lower Extremities" 16 Hours march 2016.
Evaluation and Treatment of the cervicothoracic spine, 16 Hours February 2016.