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Management for Cervical Instability

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국문요약

경추 불안정성의 관리

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척추의 기본적인 생체 역학적 기능은 신체 부분간의 운동을 허용하고 척수와 신경근을 보호하는 것으로서 이러한 기능을 수행하기 위해서는 척추의 역학적 안정성이 필수적이다. 척추의 안정체계는 수동적 근 골격계, 능동적 근 골격계, 그리고 신경계의 세 가지 하부체계로 나누어지며 이들 하부체계는 각각 독립적으로 안정성에 관여하고 있다. 경추의 불안정성의 문제는 비정상적으로 증가된 추간관절의 운동에 의해 염증성의 신경을 압박 또는 신장하거나 또는 통증수용기가 많이 분포하는 인대, 관절낭, 섬유륜과 종판에 비정상적인 변형을 일으키는 것을 말한다. 안정성의 장애는 근육의 기능적 측면에서 국소적 안정체계와 포괄적 안정체계의 문제로 구분할 수 있다. 불안정한 경추 환자의 임상적 양상은 일반적으로 머리가 앞으로 나오고 전방 전위된 자세로 견갑대와 승모근 상부의 과활동성을 나타낸다. 또한 능동운동은 감소되지 않으나 수동운동에서 분절의 회전운동과 병진운동의 증가와 종말감의 변화가 있다.

경추의 불안정성을 관리하기 위한 실험적 연구로 전반적인 근육 훈련, 고유수용기 훈련, 그리고 도수치료의 세 가지 주된 접근법이 있고 실제적인 접근법으로는 고유수용성 재활프로그램, 칼텐본-에반스 접근법, 그리고 슬링운동법 등이 있다. 각 방법들은 임상에서 나름대로의 이점이 있으며 환자의 상태에 따라 이들 방법을 단독으로 또는 병행해서 적용할 수 있을 것이다. 그러나 경추에서 이러한 방법들의 효과를 입증하는 증거는 부족하여 앞으로 이러한 방법에 대한 임상적 경험보다는 그 효과를 입증할 수 있는 연구가 필요하다고 본다.

핵심 단어 *: Cervical Instability, Stabilization, Stabilization training*

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1. INTRODUCTION

There is no doubt that neck pain is prevalent in the general population (Cote et al., 1998). Twenty-six to seventy-one percent of the adult population will probably experience an episode of cervical symptoms (Gross et al., 1999) and seventy percent of adult individuals will be affected by a neck related problem in their lifetime. Pain arising from the cervical spine is often difficult to diagnose clinically because of a multifactorial aetiology (Bogduk, 1994). Instability of the cervical spine is one of the causes of neck pain. This paper is focused on functional instability of the cervical spine and stability training.

2. DEFINITIONS

2.1 Instability

The basic concept of cervical instability is that abnormally large intervertebral motions cause either compression or stretching of the inflamed neural elements or abnormal deformations of ligaments, joint capsules, annular fibers, and end-plates which are known to have significant density of nociceptors (Wyke, 1970).

Lee (1995) divided instability into two types: mechanical and clinical. Mechanical or pathological instability refers to loss of control of the small joint movements such as translation that occur when the patient attempts to stabilize the joint during movement. Clinical instability refers to excessive gross movement in a joint and is sometimes referred to as pathological hypermobility; in nonpathological states, it is called laxity or hypermobility (Magee, 1999).

2.2 Neutral Zone

Panjabi (1992b) describes instability as the reduced ability of a motion segment to obtain its neutral zone. The neutral zone is the small range of displacement around the segment's neutral position where little resistance is offered by passive spinal restraints (Fig. 1). Magee (1999) defined the neutral zone as where there is no or a minimal resistance range in the joint during passive movements. The subtle movement in this region may increase with injury, disc degeneration and weakness of the muscles. The injury-related increase of the neutral zone was higher than that of the ROM (Kettler et al., 2002). Although the range of motion in flexion/extension did not change with increasing disc degeneration, the neutral zone increased significantly (Panjabi, 1992b). In contrast, the physiological movements can be restricted by reducing the zone causing osteophyte formation, operational fixation and by strengthening the muscles. The size of the neutral zone is considered to be an important measure of spinal stability (O'Sullivan, 2000).

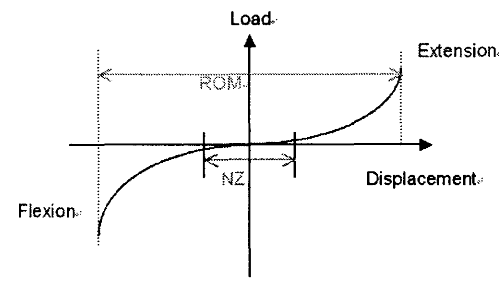

Fig. 1 Load-deformation curve (adapted from Panjabi, 1992)

3. ANATOMY

The cervical spine consists of several joints and an area in which stability has been sacrificed for mobility (Magee, 1997). It is supported by the anterior longitudinal ligament anteriorly, posterior longitudinal ligament, ligamentum flavum, interspinous ligament, supraspinous ligament posteriorly, and transverse ligament laterally. The upper cervical is supported by the alar ligament, apical ligament, and tectorial membrane. The cruciate ligament supports the dens.

There are about 30-32 muscles around the head and neck area. In the human spine, vertebrae and ligaments can support only a small perpendicular force without muscles around the vertebrae and ribs. It can lose it's stability with only a 20N weight. The combined movement of the cervical spine is the most complex in the whole vertebrae. The combined movements in the neck occur by a complex action of intervertebral muscles, suboccipital and strong paravertebral muscles (Foreman et al., 1995). The deep neck flexors which attach to the vertebral bodies and stabilize the segments are the longus capitis, longus colli, rectus capitis anterior and lateralis (Fig. 2). The sternocleidomastoid serves the role of cervical flexor and rotates the head contra laterally. It also acts as a lateral flexor.

The deep neck extensors are the semispinalis cervicis, multifidus and the short neck extensors (Fig. 3). Splenius capitis, levator scapulae, scalenus, semispinalis capitis rotate the head and neck ipsilaterally.

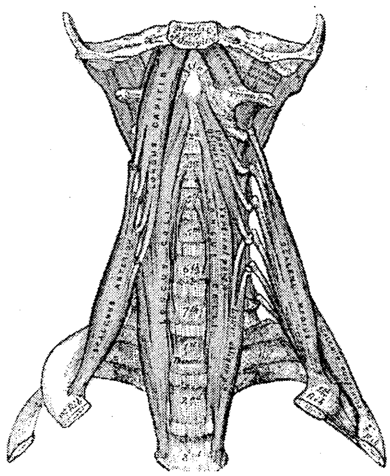

Fig. 2 Deep anterior cervical muscle (Gray, 1973)

Conley et al. (1995) studied the function of individual neck muscles using contrast shifts T2 weighted magnetic resonance imaging during exercise. They showed that the more superficial muscles have a major function in torque production. The deeper muscles, including longus capitus and longus colli anteriorly and semispinalis cervicis and multifidus posteriorly, demonstrate lesser but continued activity concomitant with a postural, supporting role.

4. SPINAL STABILIZING SYSTEM

The basic biomechanical functions of the spinal system are to allow movements between body parts, to carry loads, and to protect the spinal cord and nerve roots (White & Panjabi, 1990). Mechanical stability of the spine is fundamental to perform these functions. The spinal stabilization system consists of three subsystems which are the passive musculoskeletal, active musculoskeletal, neural (feedback) subsystems (Panjabi, 1992a). The passive musculoskeletal subsystem includes vertebrae, facet articulations, intervertebral discs, spinal ligaments, and joint capsules, as well as the passive mechanical properties of the muscles.

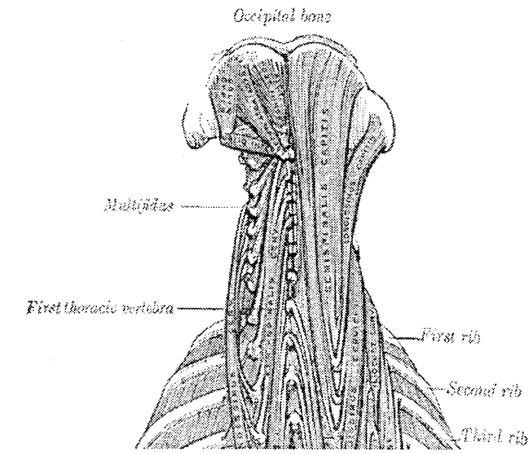

Fig. 3 Deep posterior cervical muscle (Gray, 1973)

The active musculoskeletal subsystem consists of the muscles and tendons surrounding the spinal column. The neural and feedback subsystem consists of the various force and motion transducers, located in ligaments, tendons, and muscles, and the neural control sensors (Panjabi, 1992a). These separated subsystems are functionally interdependent (Fig. 4).

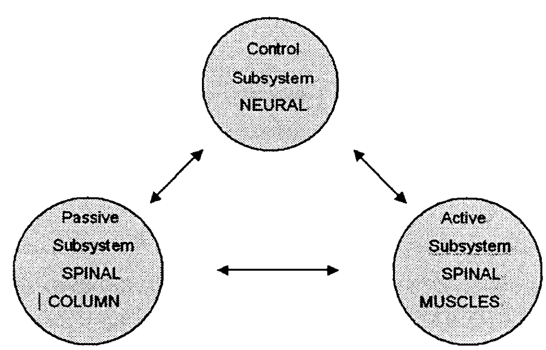

Fig. 4 Spinal stability system (adapted from Panjabi, 1992a)

4.1 The Passive (Ligamentous) Subsystem

The components of the passive subsystem can not provide any significant stability to the spine in the neutral zone. The ligaments develop a reactive force at the end of the range but these components act as a signal-producing device to measure vertebral positions and motions.

In the situation where the passive stiffness of a motion segment is reduced, the vulnerability of the spine towards instability is increased (Cholewicke & McGill, 1996).

Overstretching of the ligaments, development of tears and fissures in the annulus, development of microfractures in the end-plates, extrusion of the disc material into the vertebral bodies, and degeneration of discs can lead to passive subsystem dysfunction (Panjabi, 1992a). These factors decrease the stabilizing capacity of the passive subsystem and may cause compensatory change in the active subsystem.

4.2 The Active (Musculotendinous) Subsystem

The active subsystem such as muscles and tendons generate forces and provides stability to the spine. The force transducers in tendons measure the magnitude of the force and play a role as a part of the neural control subsystem.

Kettler et al. (2002) showed the stability role of muscles in the upper cervical area using 6 human occipito-cervical spine specimens C0-C5. One anterior (Longus capitis) and two posterior pairs of intrinsic cervical spine muscles (splenius capitis, semispinalis capitis) were simulated. The simulated muscle forces strongly stabilized C0-C2 in all loading directions and in all injury states shown by a distinct decrease of ROM and NZ. ROM was reduced to 46-58% (without muscle force simulation=100%), and NZ to 24-59%. Disuse, degeneration, and injury may decrease the stabilizing capacity of the active subsystem.

4.3 The Neural Control Subsystem

The neural subsystem collects information from various transducers and activates the active subsystem according to the demands of stability. The system is activated until stability is achieved. To achieve the required stability, the neural subsystem should perform the complex task of continuously and simultaneously monitoring and adjusting the forces in each of the muscles surrounding the spinal column. One or more muscles may fire in an undesirable manner resulting in too small or too large a force and/or a too early or too late firing. It may be due to the faulty information transmitted from the spinal system transducers or the fault of the control unit itself. Errors in the neural control subsystem may cause excessive muscle tension and lead to soft tissue injury and pain (Panjabi, 1992a).

5. THE CONCEPTS OF MUSCLE FUNCTION

The concept of local and global muscle systems and stabilizer and mobilizer muscles provide useful frameworks to classify muscle function. Local muscles have their origin or insertion at the vertebrae and are used to control the curvature of the spine and provide stiffness to maintain the mechanical stability of the spine. Global muscles are more superficial and link the thorax to the pelvis (Bergmark, 1989). The stabilizer muscles tend to have a postural holding role associated with eccentrically decelerating or resisting momentum and are mechanically able to control excessive range of motion. On the other hand, the mobilizer muscles tend to have a movement production role associated with concentric acceleration of body segments. The muscles tend to cross many segments but they do not have attachments at all segments between origin and insertion (Sahrmann, 2000).

Comerford and Mottram (2001) proposed a new model of functional classification based on these concepts. The model includes local stabilizer, global stabilizer and mobilizer muscles (Table 1). Local stabilizers have a particular role in maintaining segmental stability. Global stabilizers work eccentrically to control range of motion. Global mobilizers generate torque to produce large ranges of movement. These muscles generally work concentrically to produce power and speed, and work eccentrically to decelerate high loads. All muscles have a stability role but global mobilizers should ideally also be recruited for a stability function when under load or under high-speed movements.

Stability dysfunction can be identified in the local and global stability systems (Table 2). Dysfunction of local stabilizers is due to alteration of normal motor recruitment and a loss of motor control of deep segmental stability (Richardson et al., 1999) while dysfunction of the global stabilizer is due to an increase in functional muscle length or diminished low threshold recruitment (Gossman et al., 1982). Dysfunction of the global mobilizer is due to a loss of functional muscle extensibility or overactive low threshold activity.

6. PATHOPHYSIOLOGY AND PATHOBIO- MECHANICS

6.1 Proprioceptive Factors

In neck pain and headache patients, it is reported that there is reduced deep neck flexor activity associated with other cervical spine muscles being tight (Watson & Trott, 1993; Treleaven et al. 1994; Jull et al. 1999). Deficiency of serratus anterior may also contribute to the development of these abnormal patterns of recruitment.

Recently, attention has been given to the potential role of cervical mechanoreceptive dysfunction in chronic neck pain (Revel et al., 1991; Revel et al., 1994; Heikkila & Astrom 1996; Heikkila & Wenngren 1998), suggesting an alteration in neck proprioception. Proprioception defines the total neural input to the central nervous system from mechanoreceptors in the muscles, tendons, ligaments, joint capsules and skin (Wilkerson & Nitz, 1994). One explanation for the diminished kinesthesia findings in chronic neck pain patients involves a functional alteration in the muscle spindle receptors (Revel, 1991). This functional deficit could occur as a result of muscle pain as well as articular pain and dysfunction (Schaible & Grubb, 1993).

Table 1. The function and characteristics of the three classes of muscles (adapted from Comerford and Mottram, 2001)

Local stabilizers	Global stabilizers	Global mobilizers
- Increases muscle stiffness to control segmental motion - Controls the neural joint position - Contraction = no/min. length change ∴ does not produce R.O.M. - Activity is independent of direction of movement - Continuous activity throughout movement - Proprioceptive input re: joint position, range and rate of movement	- Generates force to control range of motion - Contraction = eccentric length change ∴ control throughout range especially inner range ('muscle active = joint passive') and hyper-mobile outer range) - Low load deceleration of momentum (especially axial plane: rotation) - Activity is direction dependent	- Generates torque to produce range of movement - Contraction = concentric length change ∴ concentric production of movement (rather than eccentric control) - Concentric acceleration of movement (especially sagittal plane: flexion/extension) - Shock absorption dependent - Activity is direction dependent - Non-continuous activity (on : off phasic pattern)

McPartland et al. (1997) found decreased standing balance and marked suboccipital muscle atrophy including fatty infiltration in chronic neck pain patients. It has been suggested that atrophy and fatty infiltration in the deep suboccipital muscles may lead to diminished or altered proprioceptive input to higher centers (McPartland & Brodeur, 1999). Andary et al. (1998) showed that in a patient with chronic neck pain and suboccipital atrophy after a forced flexion cervical injury, electromyography and magnetic resonance imaging abnormalities provided some evidence of denervation, possibly as a result of nerve damage from trauma to the C1 dorsal ramus.

Table 2. Dysfunction in the three muscle classes (adapted from Comerford and Mottram, 2001)

Local stabilizers	Global stabilizers	Global mobilizers
- Motor control deficit associated with delayed timing or recruitment deficiency - Reacts to pain and pathology with inhibition - Decrease muscle stiffness and poor segmental control - Loss of control of joint neutral position	- Muscle active shortening ≠ joint passive (loss of inner range control) - If hyper-mobile poor control of excessive range - Poor low threshold tonic recruitment - Poor eccentric control - Poor rotation dissociation	- Loss of myo-fascial extensibility limits physiological and/or accessory motion (which must be compensated for elsewhere) - Overactive low threshold, low load recruitment - Reacts to pain and pathology with spasm

6.2 Neuromuscular Factors

A mechanism for increasing joint stability through enhanced muscle stiffness is co-contraction of agonist and antagonist muscles which lie each side of a joint (Anderson & Winters, 1990). Tonic muscle fibers around the vertebrae have an important antigravity, postural supportive role. These fibers can be affected by disuse (Richardson & Jull, 1994) and by the reflex and pain inhibition associated with pain and injury (Baugher et al., 1984).

Recruiting muscles in co-contraction is considered to provide support and joint stabilization even when contractions occur at very low levels. Hoffer & Andreassen (1981) contend that contractions as low as 25% maximum voluntary contraction are able to provide maximal joint stability. In addition, feedback from the joint and ligament afferents, via their effects on the gamma spindle system, may help regulate muscle support (Johansson & Sojka, 1991).

It is now documented that chronic ailments of the motor apparatus are linked to physiological sensory motor control and muscular strength (Field & Abdelmoty, 1997). The most important changes are shown in Table 3.

Table 3. Changes associated with chronic disorders (adapted from Kirkesola 2000)

- Reduced sensorimotor control
- Reduced strength and endurance of the stabilizing musculature
- Reduced strength and endurance of the mobilizing musculature
- Muscle atrophy
- Reduced cardiovascular function

Even though it is not known with certainty how significant these changes are in connection with the chronification process, there is reason to believe that they play an essential role in sustaining ailments.

6.3 Cervical Pain and Stabilization

Recent studies have shown that chronic neck pain is associated with reduced sensorimotor function (McPartland et al., 1997; Revel et al., 1991; Revel et al., 1994; Heikkila & Astrom, 1996). Sensorimotor function includes proprioception, the perception of these signals and efferent impulses to the muscles for correcting position and maintaining stability (Higgins, 1991). It is considered that dynamic joint stability and the local muscle system are important in the treatment of segmental spinal pain (Richardson et al., 1999).

Researchers and clinicians have also identified the need to assess and rehabilitate the multi-segmental role of the global muscle stability system in the management of pain in the movement system (Sahrmann, 2000).

Mayoux-Benhamou et al. (1994) highlighted the importance of longus colli for postural control of the cervical curve and concluded that It counteracts the lordosis increment related to the weight of the head and to the contraction of the dorsal neck muscles. Furthermore, there is evidence that the upper and deep cervical flexors lose their endurance capacity in patients with neck pain (Beenton & Jull, 1994; Watson & Trott 1993). Additionally, there is preliminary evidence that restoration of the supporting capacity of upper and deep cervical flexor muscles parallels a reduction in neck pain and headache (Beeton & Jull, 1994).

Loudon et al. (1997) found that the ability of patients with whiplash to reproduce a specific position of the cervical spine is less precise compared with a nontraumatized spine.

6.4 Training The Stabilizing Musculature

Libenson (1996) defined spinal stabilization as a training process to control the unstable position, and Magee (1999) defined as the ability to control gross and fine movements consciously or unconsciously. Stabilization includes a training process to maintain neutral position to prevent microtrauma resulting from force and load.

Recent studies indicate that certain muscles have a particular stabilizing function. These muscles, called local muscles, are believed to be responsible for segmental stability, whereas global muscles perform movements (Bergmark, 1989). The most essential stabilizing muscles for the cervical column are the longus colli, longus capitis, multifidus and semispinalis cervicis (Conley et al., 1995). The longus colli has a high density of muscle spindles, which appear clustered and concentrated anterolaterally, away from the vertebral body (Body-Clark et al., 2002). The multifidus has a low density of muscle spindle, which is found predominantly as a single unit concentrated closely to the vertebral lamina. It is suggested that the muscles which have high density of muscle spindle have a role of stability.

In case of sudden movements of the arm, the body tries to stabilize the cervical column with the assistance of a feedforward mechanism (Gurfinkel et al., 1988). The local stabilizing muscles receive efferent signals and contract before the global motor muscles are activated.

There is documentation that patients with chronic pain have lost the feedforward mechanism (Hodges & Richardson, 1998).

Initial training to stabilize musculature and low-graded isometric contractions of local stabilizing muscles should be emphasized (Richardson et al., 1999; Hides et al., 1996; O'Sullivan et al., 1997). Gradually exercises are added that activate global muscles, both as stabilizers and as a dynamic movers.

7. CLINICAL FINDINGS

Torney and Niere (2000) defined symptomatic minor instability (MCI) as pain and dysfunction associated with decreased stability, but without cord, vertebral artery or nerve root involvement and is more likely to be encountered in physiotherapy clinics. The authors tried to clarify the diagnosis of MCI by surveying 153 clinicians experienced in the management of neck conditions and concluded that the clinical findings which were considered very important or vitally important in the diagnosis of MCI were history of major trauma, reports of the neck catching, locking or giving way, poor muscular control, signs of hypermobility on X-ray, excessively free end feel on passive motion testing, spondylolisthesis on X-Ray and unpredictability of symptoms.

In general, the patients show poor posture with head forward, protracted shoulder girdle and overactive upper trapezius (Janda, 1994). Active movements are not reduced but passive movements present increased segmental rotatory and translatory movements with altered end feel. Although the range of motion of flexion and extension is not changed, the neutral zone is increased (Kettler et al., 2002; Panjabi 1992b). A unidirectional or multidirectional hypermobility is possible. Neurological changes such as sensation, reflex and muscle power and nerve root irritation may occur as well as altered neurodynamic tests (Edgar et al., 1994; Grant et al., 1997). Increased tension, swelling, trigger points and irritation of teno-osseous insertions can be found in palpation. The superficial muscles present tightness, tensions and painful conditions. Lower trapezius and serratus anterior are weak (Janda, 1994; Jull, 1994). The deep neck flexors and posterior segmental stabilizers show weakness (Watson, 1994; Jull, 1997). X-rays or CT-scans in neutral position may be negative or show degenerative changes. Increased translatory and rotatory segmental movements can be observed in functional imaging in extension or flexion (Dvorak et al., 1987; Dvorak et al., 1988; Deburge et al., 1995, Li et al., 1998; Ordway et al., 1999).

8. MANAGEMENT

In this section, I will examine both experimental trials and practical approaches to treatment. General muscle training, proprioceptor training, and manual therapy are the three main approaches in the experimental trials. Practical approaches include a proprioceptive rehabilitation program, the Kaltenborn-Eventh approach and sling exercise therapy.

8.1 Experimental Trials

None of the studies investigating cervical instability included criteria regarding diagnosis of instability. Possible reasons for this may be the lack of reliable tests or measurements to detect instability. As chronic neck pain is associated with reduced sensorimotor function (McPartland et al., 1997; Revel et al., 1991; Revel et al., 1994; Heikkala & Anstrom, 1996; Loudon et al., 1997), and with the loss of endurance capacity in the upper and deep cervical flexors in patients with neck pain (Beeton & Jull, 1994), it can be considered that chronic neck pain patients have cervical instability. The following studies are the studies which investigate the effects of physical interventions for chronic neck pain patients.

8.1.1 General Muscle Training

Several studies dealt with general muscle training and reported significant effects as a result of their programs.

Levoska & Keinanen-Kjukaanniemi (1993) investigated 169 subjects who had neck and shoulder symptoms and who worked mainly at personal computers. They compared the effects of passive physical therapy including heat, massage, light stretching and physical exercise of the neck and shoulder muscles and active physical therapy including stretching and dynamic muscle training of the neck and shoulder regions using the omnikinetic training machine. They found that the occurrence of symptoms was significantly lower after active rather than after passive physical therapy.

Waling et al. (2000) found that strength, endurance and co-ordination exercises were equally superior to no treatment. Work-related neck-shoulder pain patients were divided into four groups. Three groups were given a different style of exercise, with the fourth group being a control group. A significantly larger pain reduction was found in the three exercise groups compared to the control group but there were no significant differences in comparisons between exercise groups.

Friedrich et al. (1996) compared a supervised group and an instruction group from a total number of 87 patients with neck or low back pain with symptoms. Strengthening and stretching exercise were taught individually by a physiotherapist in 8 treatment sessions to the supervised group and only a brochure was given to the instruction group. They found that the supervised group was better than the unsupervised group with regard to the quality of exercise performance, muscle status, and pain relief.

Soderlund et al. (2000) compared the effects of a standard exercise program and an exercise program that additionally included learning of skills to improve the kinaesthetic sensibility of neck muscles. They concluded that the standard exercise program seemed to be sufficient treatment for acute WAD patients.

Overall, the above mentioned studies do support the use of general exercise as a treatment or a preventative measure.

8.1.2 Deep Neck Flexor Training

There is evidence that the upper and deep cervical flexors lose their endurance capacity in patients with neck pain. There is preliminary evidence that restoration of the supporting capacity of the upper and deep cervical flexor muscles parallels a reduction in neck pain and headache (Beeton & Jull, 1994).

One case control study (Grant et al., 1997) investigated the effects of active stabilization training for screen based keyboard operators. The training consisted of upper cervical flexion holding and lower scapula stabilizing exercises. The authors showed significant improvement in the holding capacity, muscle length, ULTT, and joint symptoms of their patients.

Jull et al. (2002) compared the effects of manipulative therapy and exercise therapy and combined both therapies for cervicogenic headache. The authors applied a new low-load exercise program emphasizing muscle control to correct head posture. The exercise program consisted of craniocervical flexion exercise, serratus anterior and lower trapezius training, lengthening exercises for tightened muscles and postural correction. All three treatments were effective in reducing headache and neck pain and this was maintained over a follow up period of 12 months. The participants who received the combined treatment of manipulative and exercise therapy were 10% better than the participants who received one therapy only.

Beeton & Jull (1994) applied the same regimen as Jull et al. (2002) in a single case study. Their patients adopted home exercise only at the last six-week phase and showed further improvement following the six-week combined treatment phase.

8.1.3 Proprioceptive Rehabilitation Training

Some studies have shown that sensorimotor exercises for patients with chronic neck pain are effective (Revel, 1994; Fitz- Ritson, 1995; Taimela et al., 2000).

Taimela et al. (2000) demonstrated that chronic neck pain patients receiving 24 sessions of multimodal treatment including proprioceptive exercises faired better than those who exercised at home, or just received advice. Exercise for the active group consisted of cervicothoracic stabilization, relaxation and behavioral support to reduce anxiety and fear of pain, eye fixation exercises and seated wobble-board training to improve postural control. The active group of patients experienced significantly fewer neck symptoms, greater general health, and improved working ability at 3 and 12 months follow-up.

Fitz-Ritson (1995) compared the "chiropractic plus phasic exercises" to "chiropractic plus standard exercises" for vehicle accident patients and found a remarkably significant difference favouring the phasic exercises (48.3%) in comparison with the standard exercise group (7.4%). Phasic exercise means a coordinated pattern of exercise for eye-head-neck-arm and eye-head-neck-trunk. However, this study did not apply adequate statistical analysis in comparing groups.

Revel et al. (1994) investigated the effects of eye-neck coordination exercise for chronic neck pain patients to improve head positioning accuracy. At the 10 week follow-up, a greater gain in head repositioning accuracy was observed in the rehabilitation group than in the control group. Other clinical parameters such as pain, drug intake, range of motion, and self-assessed functional improvement were also more improved in the rehabilitation group than in the control group. The authors suggested that a rehabilitation program based on eye-head coupling should be included in most medical management of cervicalgic patients.

8.1.4 McKenzie Exercise

Kjellman & Oberg (2002) supported the use of McKenzie exercise rather than general exercise. General exercise included exercises of the neck and shoulders was intended to increase cervical movement and the endurance and strength of cervical muscles through active movement. The McKenzie exercise program followed the McKenzie protocol but choose the type of exercise, the number of treatment sessions and home exercise to suit the individual patients. The two exercise groups were better than the control group but the McKenzie treatment was more successful than general exercise or the control group during the first 3 weeks. It can be concluded on the basis of these studies that different forms of active exercise may be effective in treatment of neck pain but more studies are needed to define the optimal forms of exercise or exercise combinations in treatment of neck pain.

8.1.5 Manual Therapy

Bronfort et al. (2001) showed that manipulation (the high velocity thrust technique used by chiropractors) plus low-tech exercise, including progressive strengthening exercise for the neck and upper body, was superior to manipulation alone at the one year follow-up for the cumulative advantage of pain intensity. The treatment duration was 11 weeks or 20 sessions of treatment for chronic neck pain. Evans et al. (2002) continued a two year follow-up for the study of Bronfort et al. (2001) with similar findings; the findings of Evans et al. (2002) were impaired due to a high rate of non-return of follow-up questionnaires by patients (24%).

Allison et al. (2002) studied mobilisation based on neural stretch and manual therapy based on articular mobilisation for the cervicobrachial pain patients. Each group were given home exercise based on neural and articular mobilisation respectively. They found significant improvement in both exercise groups but they could not find any differences between the two intervention groups.

Hoving et al. (2002) favored manual therapy rather than exercise combined with other physical treatments for non-specific neck pain patients. The authors compared general physiotherapy including exercise with manual therapy with continued care by a general practitioner. The physiotherapy group received active exercise therapy (active exercise, postural, stretching, relaxation and functional exercise), manual traction, stretch, massage and physical therapy methods such as interferential current and heat twice a week for six weeks. For the manual therapy group, mobilisation, coordination or stabilization techniques were performed once a week for six weeks. Advice on prognosis, psychosocial issues, self-care, and ergonomics were provided by a general practitioner for the continued care group. They found significant change in pain intensity with manual therapy compared with continued care or physical therapy, even though physical therapy scored better than continued care on some outcome measures. Their findings supported the use of manual therapy rather than physiotherapy or continued care by a general practitioner. However, the study did not focus on exercise interventions, the degree of difficulty of exercise was not clear and each patient did not receive the same exercise program.

McKinney (1989) supported home instruction in early mobilisation for WAD patients. They showed better recovery, reduced symptoms and shortened the period they needed to wear a collar.

8.2 Practical Procedures

Co-contraction of agonist and antagonist has been considered by several researchers in relation to joint stabilization strategies (Anderson & Winters, 1990). This type of muscle activity is linked to increasing joint stiffness and support independent of the torque producing role of muscles (Carter et al., 1993). There are several approaches to increase cervical stability and proprioceptive sensibility and I will discuss them in this section.

8.2.1 Proprioceptive Rehabilitation Program

The purpose of the proprioceptive rehabilitation program is to improve neck proprioception and to decrease pain and discomfort. This program is base on Revel et al. (1994).

In supine position
- The therapist rotates the patient's head slowly.
- The patient maintains his/her gaze on a fixed target.
- During the movement, the patient concentrates on the different positions of the head.

In sitting and standing position
- The patient wears special goggles which have restricted peripheral vision except a clear central point, 0.5 mm wide.
- The therapist moves the target slowly in a horizontal plane.
- The patient follows the target with active movements (mainly rotations).
- The patient gazes on a fixed target while the therapist moves the patient's trunk.
- The cervical movement occurs automatically.

Head relocation training in sitting and standing
- The patient fixes a target for a few seconds and memorizes the head-neck position.
- Close the eyes and rotate the head maximally.
- Rotate the head to find the initial position.
- Open the eyes.
- Repeat the exercise to relocate as accurately as possible the initial head position.

An example of the targets being used for the proprioceptive rehabilitation program is showed in figure 5.

Exercise in a wide range of movement
- Therapist moves a target slowly in a horizontal plane.
- The patient follows the target with free eye-head coupling.

These exercises are conducted in 15 individual exercise sessions twice a week.

8.2.2 Cervical stabilization Training

These techniques are based on my personal experience at a course of the 'Kaltenborn-Evjenth-Concept' method in 1999.

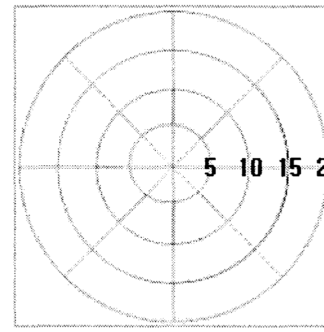

Fig. 5 An example of the targets for the proprioceptive rehabilitation program

Cervical Extensor training
In sitting position
- The patient sits on the edge of the table.
- With chin tucked, lean the body forward, looking at slightly lower than the eye level and feel the deep muscles in the cervical spine.
- Look up at a higher level, lean forward, and feel the tension in the deep muscles of the neck.
- In this position, stand up slowly whilst relaxing the shoulder muscles.

In kneeling position
- Straighten the body and lean body forward progressively.

Progression of Cervical Extensor Training
In Sitting position
- Hold one end of the theraband with the mouth and hold the other end with the hands.
- Pull the theraband using neck muscles.
- Place the theraband around the neck and hold the ends with both hands.
- Pull the theraband using neck muscles (Fig 6).

In quadruped position
- Put the theraband around the neck and hold the ends with both hands.
- Pull the theraband using neck muscles.

Training of Longus colli

In supine position

- Therapist holds the patient's head.
- Therapist pushes down the occiput in a caudal direction at the same time pulling the forehead in a cephald direction. The patient resists the force isometrically (Fig 7).

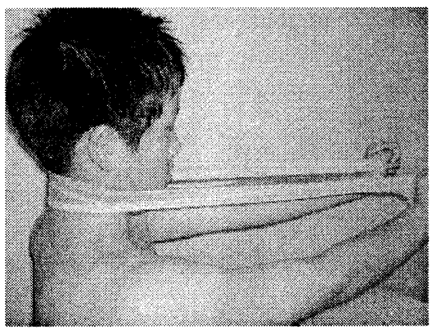

Fig. 6 Progression of cervical extensor training in sitting position

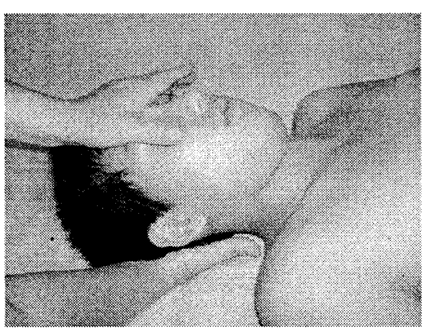

Fig. 7 Training of Longus colli in supine position

In supine position

- Place a sandbag under C2.
- Patient pushes the sandbag and holds 4-5 seconds.

In supine position

- Therapist pushes down on the area between both eyes and the patient tries to lift his/her head up.

In sitting position

- Therapist holds the patient's chin and pulls forward, the patient resists the force.

Self exercise in standing

- Patient stands with back on the wall.
- Pull thoracic forward at the same time lifting the head upward.

Segmental stability training

Traction technique

- The patient is in supine position.
- Therapist fixes the lower level vertebra by holding vertebral arch with thumb and index fingers.
- The other hand holds upper level vertebra with thumb and index fingers.
- Therapist pulls the upper level in a cephalic direction and patient resists isometrically.
- Start from normal segment of spine.
- Therapist pulls the upper level vertebra in a transverse (upward) direction with one hand holding lower level from spinous process to transverse process with index finger.
- The patient resists isometrically.

Flexion technique

- The patient in supine position.
- Therapist holds spinous process with both index fingers and pushes in direction of flexion and patient resists in direction of extension isometrically.
- The force can be applied various directions.
- This technique also can be done lying on side.
- As progress improves more pressure can be applied without upper trapezius activation.

Stabilization in Sitting

- Therapist pushes the spinous process in a cranial ventral direction with both thumbs and the patient resists isometrically.
- The force can be applied unilaterally.

8.2.3 Sling Exercise Therapy

The sling exercise therapy concept, which has been developed in Norway over the past eight years, consists of a system of diagnosis and treatment. The system of diagnosis involves testing of muscles' tolerance through progressive loading in open and closed kinetic chains. The treatment system contains elements such as relaxation, increasing the range of movement, traction, training the stabilizing musculature, sensorimotor exercises, training in open and closed kinetic chains, dynamic training of the mobilizing musculature, fitness training, group exercise and personal exercise at home (Kirkesola, 2000). The sling exercise therapy for cervical instability is introduced in this paper. The advantage of using the sling is to eliminate the effects of gravity on any part of the body. The following methods are suggested to increase cervical stability.

Relaxation exercise

- Lying on their side, the patient's head is suspended by the sling and maintained in neutral position.
- The patient flexes and extends the neck slowly. The chin should not be protracted in flexion.
- In relaxed supine position, the patient slowly moves the head to the right and left alternatively. The shoulder should not be elevated with substitution.
- In relaxed supine position, the patient slowly rotates his/her head to the right and left alternatively. The sling follows the motion of the pulley system. The pulley system allows the sling's movement facilitates.

Sensorimotor training in closed kinetic chain

The emphasis is on closed kinetic chain exercises on an unstable surface, thereby achieving optimum stimulation of the sensorimotor apparatus (Fig 8).

- In supine position, two air cushions are positioned under the patient's head.
- The body is suspended at three points, scapula, pelvis, and ankle area by slings.
- The patient moves his/her neck slowly.

Sensorimotor training in open kinetic chain

- In sitting position, air cushions are positioned under the patient's buttocks and feet to make an unstable supporting area.
- The patient performs lateral flexion against resistance without moving his/her body.
- The patient flexes his/her neck without protracting his/her chin.

Flexor stabilizing training

- The patient sits on the floor with hips and knees bent.
- Buttocks placed 80 cm behind the ropes' suspension point and the ropes held in hands.
- Pull the chin in slightly and slowly lean the upper body back slightly.
- Hold the position and come back (Fig. 9).

Fig. 8 Sensorimotor training in closed kinetic chain

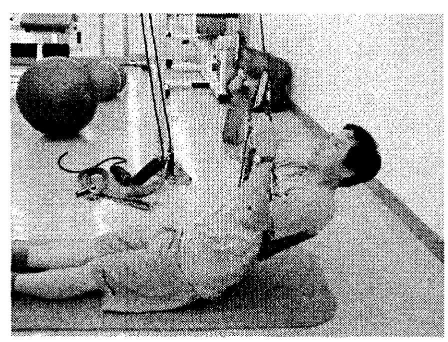

Fig. 9 Flexor stabilizing training

Extensor stabilizing training

- The patient lies on stomach with the head extending over the end of a bench.
- Pull the chin in and then slowly move the head back (keep the neck straight).
- Hold the position and relax.

Stabilizing exercise

- In relaxed supine position with his/her head suspended by the elastic sling.
- The patient retracts cervical spine and holds several seconds.
- The same exercise is performed lying on side for lateral stabilization.

Strengthening exercise

- In supine position, the patient's head is suspended by the sling and maintained in neutral position.
- The patient laterally flexes his/her head against resistance.
- The same exercise can be conducted lying on side to strengthen cervical extensors and flexors.

8.2.4 Active Stabilization Training

This method is provided by Jull (1997). This exercise is focused on training deep neck flexor muscles and correct posture. Further details of this method can be found in the Jull's lecture note in my bibliography.

9. CONCLUSION

Definitions of common terms, basic anatomy, pathophysiological and pathobiomechanical issues, clinical findings and the management of cervical instability are presented in this paper. While reviewing the literature several concepts to increase cervical stability were recognised. Each concept has their own advantages in the clinical situation. These methods or combined methods can be used according to the situation of the patients. It should be emphasized that the suggested management is only a proposal and readers are encouraged to use the provided knowledge as guidelines, which should be adapted to the patient by using clinical reasoning strategies and not as a standard procedure. However, there is lack of evidence to prove the effects of these concepts. Most research was performed to prove the effects of lumbar stabilization exercises. For cervical vertebrae, the same principles can be adopted as for lumbar vertebrae but different techniques are needed for cervical vertebrae. The new methods need to be proven by research rather than clinical experience. More research is needed for cervical vertebrae.

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