

Sorting-out Patients with Cervico-Brachial Syndrome

Wayne Rath, PT, Dip MDT
President, Director of Treatment and Research Services
Duffy-Rath Physical Therapy, PC
115 Fairgrounds Drive, Suite 2
Manlius, NY 13104
waynerath@aol.com

I. Introduction

Cervico-brachial syndrome is now challenging low back pain as the most costly musculoskeletal disability (Mayer 1999). The pattern of incidence, natural history and socioeconomic impact is strikingly similar to low back pain. Most cases resolve in a short period of time with minimal health care costs. However a small percentage of cases become chronic, recalcitrant and represent the majority of the costs associated with this group of disorders. These difficult cases have tremendous health care costs, often without functional resolution. Almost all ultimately become a chronic pain disability. The physical therapist can play a major role in the effective and efficient management and prevention of these common disorders provided they are able to 'sort-out' the individual's problem and get at the root-cause(s).

Brief Description of Course:

This workshop is designed for licensed physical therapists that treat patients with upper back, neck and upper limb disorders. The focus is the process for sorting-out the most common biomechanical, physiologic and pathological causes for this group of patients. The workshop will use a combination of instructional modalities, including: short lecture, practical sessions, clinical simulations and reviews, patient demonstrations and ongoing discussions.

Instructional Objectives - upon completion of this activity, participants will be able to:

1. Detail the key elements of a successful patient history-taking process with patients with cervico-brachial syndrome.
2. Delineate the essential examination procedures that are required to expose the most relevant clinical signs of patient's with cervico-brachial disorder.
3. Highlight the basic clinical guidelines for development of an appropriate treatment strategy to gain control over the patient's symptoms, signs and functional difficulties.
4. Outline the reassessment and treatment process attempting to maximize the effectiveness and efficiency of treatment outcome.

Instructor (Wayne Rath, PT, Dip MDT)

Wayne graduated from the Physical Therapy Program at Downstate Medical Center, Brooklyn, New York in 1975. His initial orthopedic training was with James Cyriax, MD and John Mc. Mennell, MD (was an assistant instructor 1978 - 1983). In 1978 he started teaching at the

Physical Therapy Program UMDNJ/Kean College in New Jersey (1978 – 1985) where he developed and taught the orthopedic and joint mobilization unit. In 1985 he started teaching at the Physical Therapy Program, Thomas Jefferson University, in Philadelphia. He developed a course regarding assessment and treatment of back and neck pain, and taught one semester of kinesiology related to diagnosis and treatment of musculoskeletal disorders. He was co-founder and officer for the New Jersey Orthopaedic Section, the New Jersey Orthopaedic Study Group and the Central New Jersey Orthopaedic Study Group. In 1982 he was a founding member of the McKenzie Institute, and was on the board of directors until 1993. He co-developed the Part C course (1986) and developed the international standardization of the Part D course (1996). During his tenure with the Institute he taught more courses than any other instructor and consistently received the highest critique ratings for which he received several awards. In 1985 he introduced Mulligan Manual Therapy to the Eastern United States, and was a sanctioned Mulligan instructor until 2000.

Wayne went into private practice in 1978, and co-founded Twin Boro Physical Therapy in 1979. He and Jean co-founded the Spine Center of New Jersey in 1985, and Summit Physical Therapy in Syracuse, NY in 1992. Wayne and Jean are currently in private practice (Duffy-Rath Physical Therapy) in the Manlius, NY region providing on-site industrial services (treatment, prevention, wellness and consultation) and have a busy out-patient, musculoskeletal private practice. Their approach to the treatment and prevention of musculoskeletal disorders is called, the “Duffy-Rath System©”, and is implemented at numerous facilities throughout the country and several international sites. They have numerous publications and have provided workshops about the assessment, treatment and prevention of musculoskeletal disorders and disability throughout the world for almost 25 years. Their system, and consequently their practice, is in a constant state of evolution and growth.

General Goals of Assessment & Treatment of Musculoskeletal Disorders

The patient’s musculoskeletal problem is clinically expressed as symptoms, signs, interference with normal activities of daily living (ADL), and the patient’s cognitive, psychological and emotional response to their unique difficulty to perform their normal ADL (home, work and play). Therefore, the efficacy of our interventions is measured by the ability to eliminate or control these signs and symptoms, and remove their interference with the patient’s normal ADL. This is how we challenge ourselves to prove the applied truth of our clinical and therapeutic conclusions, clinical models and therapeutic strategies. In our approach to treatment this challenge is accepted and measured one patient at a time.

Epidemiology

Incidence - the vast majority of adults will experience back and neck pain episodes at some point in their lifetime. It is generally recognized that about 80 % will experience a low back pain episode, and 70 % a neck pain episode. These episodes, for most people, are transient, but highly recurrent. Point prevalence for back pain is approximately 18 % and neck pain 22 %.

Episodes of back and neck pain in the middle years of life. Low back pain disorders are most prevalent in the population between the ages of 40 – 45 years, and neck pain between 45 – 50

years. The incidence of these disorders will generally diminish after the age of 55 years. Low back disorders affect males slightly more than females. Neck pain disorders affect females slightly more than males.

Most evidence suggests that back and neck pain is a normal life experience, and has been since recorded medical history. In modern times, a recent trend has been the alarming rise of low back and neck pain disorders as a reason for medical disability. Evidence suggests that this is, in part, a social problem (dilemma), fueled in part by ineffective medical/healthcare interventions, the wrong clinical modeling (biomedical vs. biopsychosocial), and socioeconomic support systems that had not been available to the general population in previous generations. It is estimated that 10 % of the cases will become chronic, with 5 % of the population becoming disabled. Whiplash injury/trauma appears a significant factor in both instances.

Natural history – episodes of back and neck pain are almost always self-limiting. In general, a neck pain episode will resolve within 3 – 5 days, and a low back pain disorder within 2 – 3 weeks. Most people that experience an acute episode of back or neck pain do not seek healthcare (orthodox or heterodox) to resolve their problem. Approximately 10 – 12 % do seek formal medical or health-care attention, a very interesting statistic that requires much further evaluation from a multidisciplinary perspective.

The presence of radicular signs and symptoms does reduce the favorable prediction for spontaneous recovery in both percentage and time. The general consensus is that 80 – 90 % will recover within 4 – 6 months for brachial neuralgia and 9 months for lumbar radiculopathy, and 95 – 97 % within a year's time. There is a growing body of evidence to suggest that psychosocial factors are key predictors of a slow or poor recovery response.

There appears to be a similar outlook for the resolution of recurrent episodes. This is one of the reasons to focus our clinical concern to the individual's response to the problem, for it's almost certain that they will experience the problem again. The key is to keep the problem to a minor, inconsequential experience that does not lead to long-term impairment or disability.

Risk factors – activity-related neck pain is associated with poor posture, anxiety and depression, neck strain, occupational injuries, or sports injuries. Since many neck pain disorders are recurrent, a risk factor for an episode is the history of having experienced one previously. Simultaneously, a predictor for a time loss accident at work is the history of a previous time loss accident. There is a growing body of evidence over the past 20 years that the greatest predictors for the development of chronic pain, disability and failure to respond to sound treatment interventions of all sorts (conservative to surgery) are psycho-social.

As a physical therapist we have a proclivity towards a mechanical perspective and belief regarding causation and cure. Unfortunately many of the physical factors studied are not as predictive as expected and mechanically-based treatments don't always work. The following are some of the physical factors that have evidence to increase risk of developing a neck/arm problem:

- Prolonged sitting or motor vehicle operation.

- Twisted and bent positions, uncomfortable postures.
- Highly repetitive work.
- Heavy, frequent bending and lifting.
- Physical mismatch between work demands and physical capability.
- Vibration.

Costs of Neck Pain

The costs associated with neck/arm pain disorders mirrors that of the low back/leg pain syndromes. The average medical and compensation cost is far greater than the average for other claims. This statistic is skewed by the extraordinary cost of a small subgroup of the population; i.e. 10 % of the cases represent 80 – 90 % of the costs.

According to Mayer (1999) the mean cost of a UEMSD was 10 times greater than the median cost (\$ 8,070 vs. \$ 824 – 1992 dollars). This small sub-group should be a primary target for research and clinical intervention strategies.

Duration of Absence from work following whiplash: almost 50 % by 4 weeks and 80 % by 6 months have returned to work. Only 2.9 % remain out of work after one year, with secondary injury a significant factor. Taken from the Quebec WAD Cohort Study, Spine 20 (8S): 16S, 1995.			
Duration of Absence	All Subjects	Whiplash Only	Whiplash + Other Injury
1 week	621 (22.1 %)	383 (24.7 %)	238 (18.9 %)
4 weeks	709 (25.2 %)	360 (23.2 %)	349 (27.7 %)
8 weeks	422 (15.0 %)	223 (14.4 %)	199 (15.8 %)
26 weeks	542 (19.3 %)	317 (20.5 %)	235 (17.9 %)
52 weeks	435 (15.5 %)	238 (15.3 %)	197 (15.6 %)
> 52 weeks	81 (2.9 %)	30 (1.9 %)	51 (4.1 %)

II. Functional Anatomy, Biomechanics & Physiology

A pre-requisite to having a systematic approach to assessment, treatment and prevention is a sound working knowledge of anatomy, bio-mechanics and physiology. The following is a review of fundamental concepts related to this workshop.

The Lower Cervical/Upper Thoracic Motion Segments - the motion segments are the basic functional units of the spine (O/A-C1 to L5-S1). With the exception of O/A – C1-C2, the spinal motion segment consists of the vertebra, the intervertebral discs and the connecting ligamentous and soft tissue structures of two adjacent vertebra. An analysis of the response of the motion segment to load, position and movement provides the clinician with an insight into the mechanical function and response of the spinal joints to various examination and treatment procedures, as well as ADL function. The motion segment is an excellent tool for educating and training the patient in spine care management.

Typical cervical vertebra (C3 – 6) – the cervical vertebrae are small with a body that is broad transversely, and characterized by a well developed uncinat processes at the superior and postero-lateral surface, which gives these vertebrae a saddle-shape. The pedicles are short and project postero-laterally, the lamina are long and connect to form a short, bifid spinous process.

The transverse processes form a gutter through which the spinal nerve exits, projecting antero-lateral, and contain the foramen transversarium. The superior and inferior articular processes form an articular pillar at the junction of the pedicle and lamina. The articular facets lie in the transverse plane, at an inclined angle of approximately 45 degrees from posterior to superior. Thus, the inferior facet points down and forward. The superior facet points upward and back. The vertebral foramen is large and is triangular in shape, with the base anterior and the apex posterior.



Vertebra prominens (C7): this is a unique cervical vertebra. It has a long, thick spinous process which provides the caudal anchor for the nuchal ligament and attachment for many powerful muscles of the shoulder girdle and head/neck. It is also a transitional vertebra, connecting the highly moveable cervical spine to the rigid thorax. Consequently, there is a difference in the shape and orientation of the superior and inferior articular facets. The transverse processes are large, especially the posterior portion.



Thoracic vertebra - the thoracic vertebra gradually increase in size caudally. They are distinguished by costal facets on the postero-lateral portion of the vertebral bodies, and the lateral portion of the transverse processes to provide articulation with the ribs (except for the last 2-3 levels). The vertebral foramen is relatively small and circular in shape. The pedicles are short and do not diverge as in the cervical region. The lamina are short and strong. The articular facets lie in the frontal plane, with the superior facet facing posterior and the inferior facet facing anterior. The spinous processes slant back and downwards, except for T1 which is shaped like C7 and often times more prominent.



Bio-mechanical Considerations – understanding the mechanics of the lower cervical and upper thoracic spine is critical to sorting-out cervico-brachial disorders.

The lower cervical spine has motion available in all three planes, and the upper thoracic spine in the sagittal and axial only as the ribs prevent side-bending. However, whether or not the lower cervical and upper thoracic segments move at all in extension or the lateral motions is dependent upon the posture from which the motion is tested or performed.

When the back (lumbo-pelvic and thoracic spine) is slouched the head and neck is thrown forwards and the lower neck and upper back is positioned at end range flexion. This has been well known and researched for many years. Consequently, upon attempting to extend the neck, unless the posture is corrected (what we call ‘axial alignment’), the motion occurs in the upper cervical segments. This is illustrated in the x-rays below (from left to right: axial alignment, slouched, extend from slouch, extension from axial alignment).



The first key point of control for axial alignment is the chest position, the second is the pelvis and the third is the degree of tension in the lateral soft-tissue structures. I do not use cervical retraction unless I am looking for a tool to flex the upper or middle cervical segments, as it does not improve the mechanics of extension in the lower cervical and upper thoracic spine and further than axial alignment.

Axial alignment – the position of the spine when it is at its greatest length, and the 3 curves of the individual's spine are normalized.

Musculature of the Back & Neck: we have organized the spinal musculature from an 'axis of motion' perspective (back, front and side), a region perspective (upper and lower), and additionally the back musculature is divided into three layers; superficial, intermediate and deep. This is a useful organization for your mechanical/functional (clinical) thought process.

1. Back Musculature - this group lies posterior to the central axis of the spine and therefore provides power and dynamic support in extension +/- rotation and lateral flexion.

Superficial

Upper - trapezius, semispinalis capitis, splenius capitis, levator scapula, rhomboid major & minor, supraspinatus, infraspinatus, deltoid, teres major & minor, latissimus dorsi, serratus anterior.

Lower – latissimus dorsi and thoracolumbar fascia, serratus posterior, internal & external obliques, gluteus maximus and medius with gluteal aponeurosis.

Intermediate

Upper – longissimus capitis, semispinalis capitis, splenius cervicis, iliocostalis cervicis & thoracis, serratus posterior superior.

Lower – erector spinae (iliocostalis thoracis & lumborum, longissimus thoracis & lumborum, and spinalis thoracis & lumborum), transverse abdominus and aponeurosis.

Deep

Upper – rectus capitis posterior major & minor, superior & inferior obliquus capitis, rotatores cervicis & thoracis (longus & brevis), interspinalis cervicis, levator costae, multifidus.

Lower – levatore costarum brevis & longus, interspinalis lumborum, rotatores longus & brevis, multifidus, intertransversi, quadratus lumborum, and deep thoracolumbar fascia.

2. Front Musculature – this group lies anterior to the central axis of the spine and therefore provides power and dynamic support in flexion, rotation and lateral flexion.

Upper – sternocleidomastoid, supra & infra hyoid groups, rectus capitis, longus capitis, longus colli, anterior/middle/posterior scalene, platysma.

Lower – internal and external intercostal, transversus thoracis, internal & external obliques, rectus abdominus, transverse abdominus, psoas major & minor, iliacus.

3. Side Musculature – this group lies lateral to the central axis of the spine and therefore provides power and dynamic support laterally.

Upper – rectus capitus lateralis, anterior/middle/posterior scalene, sternocleidomastoid, upper trapezius, platysma.

Lower – internal and external intercostal, quadratus lumborum, internal & external obliques, transverse abdominus, gluteals and thoracolumbar fascia.

The muscles can be a source of relevant symptoms, both direct (produces symptoms) and indirect (related to problem, but doesn't produce the symptoms).

Journey to the Arm of the Lower Cervical Roots

Root – Trunk – Cord – Peripheral Nerve

Brachial plexus– is formed by the ventral rami of C5 – T1 (there may be contributions from C4 and T2), then runs a course directed lateral, anterior and inferior into the upper limb. This course extends from the posterior cervical triangle, between the clavicle and first rib into the axilla and eventually into the arm and shoulder girdle.

The ventral rami of the C5 – T1 nerve roots form 3 trunks (superior, middle and inferior) that divide into anterior and posterior divisions to form 3 Cords (lateral, medial and posterior) that form 5 Terminal Branches (musculocutaneous, axillary, radial, median and ulnar nerves).

Supraclavicular branches from roots of plexus: <ul style="list-style-type: none"> • To scaleni & longus coli (C5,6,7,8) • To join phrenic (C5) • Dorsal scapular (C5) • Long thoracic (C5) 	Supraclavicular branches from trunks of plexus <ul style="list-style-type: none"> • To Subclavius (C5,6) • Suprascapular (C5,6)
--	---

C-5: the root exits at C4 – 5. The ventral rami proceeds antero-lateral to contribute to the superior trunk, which contributes to the lateral cord (anterior division) and posterior cord (posterior division). Through the lateral cord, C5 contributes to lateral pectoral, musculocutaneous and lateral root of the **median nerve**. Through the posterior cord, C5 contributes to the upper and lower subscapular and the **radial nerve** (radial nerve = C5,6,7,8, T1).

C5 Dermatome	C5 Myotome	C5 Joint Movements
Lower neck, around upper trunk, A-L shoulder, arm and forearm to base of wrist.	Rhomboids, deltoids, supraspinatus, infraspinatus, teres minor and biceps.	Shoulder abduction & external rotation, elbow flexion.

C-6: the root exits at C5 – 6. The ventral rami proceeds antero-lateral to contribute to the superior trunk, which contributes to the lateral (anterior division) and posterior cords (posterior division). Through the posterior cord, C6 contributes to the upper and lower subscapular and the **radial nerve** (radial nerve = C5,6,7,8, T1).

C6 Dermatome	C6 Myotome	C6 Joint Movements
Upper back extending to the shoulders and lateral arm and forearm into the thumb.	Serratus anterior, lat, subscapularis, t-major, pec major (clav.), biceps, coraco-brachialis, brachialis, brachioradialis, supin., ECRL.	Shoulder adductors & medial rotators, elbow flexors.

C-7: the root exits at C6 – 7. The ventral rami proceeds antero-lateral to contribute to the middle trunk, which contributes to all three cords (anterior division to lateral medial cord, posterior division to the posterior cord). Through the lateral cord, C7 contributes to the lateral pectoral, **musculocutaneous** and the **medial nerve** (lateral root). Through the medial cord, C7 contributes to the **ulnar nerve**. Through the posterior cord, C7 contributes to thoracodorsal and **radial nerves**.

C7 Dermatome	C7 Myotome	C7 Joint Movements
Upper back extending to the shoulders and posterior arm and forearm into the hand and 2 nd and 3 rd digits (anterior and posterior).	Serratus anterior, latissimus, pec major (sternal), pec minor, triceps, pronator teres, FCR, FDS, ECRL, ECRB, ED, EDM.	Elbow extensors, pronation, wrist flexion and long finger flexion and extension.

C-8: the root exits at C7 – T1. The ventral rami proceeds antero-lateral to contribute to the inferior trunk, which contributes to the medial (anterior division) and posterior (posterior division) cords. Through the medial cord, C8 contributes to medial pectoral, medial cutaneous (arm and forearm), **ulnar** and medial root of **median nerves**. Through the posterior division, C8 contributes to the thoracodorsal and **radial nerves**.

C8 Dermatome	C8 Myotome	C8 Joint Movements
Across upper back extending to postero-medial arm and forearm into the hand and 4 th and 5 th digits (anterior and posterior).	Pec major (sternal), pec minor, triceps, FDS, FDP, FPL, PQ, FCU, ECU, APL, EPL, EPB, EI, APB, FPB, OP.	Elbow extension, pronation, long finger flexion and extension, intrinsic hand.

T-1: the root exits at T1 - 2. The ventral rami proceeds antero-lateral to contribute to the inferior trunk, which contributes to the medial (anterior division) and posterior (posterior division) cords. Through the medial cord, T1 contributes to medial pectoral, medial cutaneous (arm and forearm), **ulnar** and medial root of **median nerves**. Through the posterior division, T1 contributes to the thoracodorsal and **radial nerves**.

T1 Dermatome	T1 Myotome	T1 Joint Movements
Across upper back extending to antero-medial arm and forearm to the wrist.	FDP, Hand Intrinsic (except APB, FPB, OP).	Intrinsic hand.

Thoracic spinal nerves – the thoracic ventral rami lie between the ribs, with the exception of the 12th which lies below the last rib. Peripherally these are named the intercostal nerves, with the 12th called the subcostal. Cyriax felt that scapular retraction increased the tension on the thoracic nerve roots, and included this in his examination procedures.

Mechanical Effect of the Extra-segmental Structures on C/T Motion

The extensibility of the multi-joint structures that connect the lower neck and upper back to the shoulder girdle and arm require special attention during the assessment and treatment process. The presence or absence of motion loss and the effect of movement on the patient's symptoms is a critical component of the Duffy-Rath System®. It is therefore essential to determine whether

movements are limited within the motion segment(s), from something external to the motion segment, or from a combination of both. The following are a list of external structures which merit strong clinical consideration and attention in cervico-brachial syndrome:

- the dura mater
- the spinal nerve root complex
- the trunks/cords of the brachial plexus
- the peripheral nerves
- the lateral 'strap' muscles of the neck and shoulder girdle
- the various myofascial tunnels

Knowing how to increase and decrease the mechanical tension in or related to these structures (neural tension tests do not apply tension to nerves, and thankfully so) in specific regard to spinal movements, positions and activities is critical to bio-mechanical assessment and intervention.

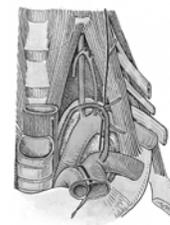
Common Sites for Adverse Tension

There are three basic sites where adverse neural tension occurs in the lower cervical/upper thoracic spine and thoracic outlet; 1) within the spinal foramen/nerve root complex, 2) within the thoracic outlet itself, and 3) in the axilla/arm. You need to localize where the tension is to the best of your ability. I use the following sequence to attempt to sort this out:

I-V Foramen – there will be 2 basic problems within the foramen; entrapment of the nerve root (disc, osteophyte, stenosis, tumor, ligamentous hypertrophy etc.) or tethering of the dural sleeve to a fixed structure in the foramen limiting its extensibility. The entrapment will present with an increase of the relevant symptoms with movements that close down the foramen, regardless of whether there is upper limb tension present or not. Symptom production with the adherence will be dependent upon increasing tension through the upper limb system.

As with the lumbar spine, disorders affecting the foramen are divided into zones; medial (entrance), middle, lateral (exit) and extraforaminal. However the shape and structure of the foramen is different in the cervical spine. The nerve root is situated in a groove that extends from the medial border of the pedicle to the lateral end of the transverse process, terminating with an anterior and posterior tubercle. The cervical roots are fixated in this groove and occupy a greater percentage of the space. This renders them more vulnerable to entrapment and adherence.

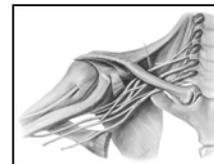
Thoracic Outlet – there are several areas within this region where the neuro-vascular structures can become entrapped or tethered. These sites include as the trunks pass through the scalene, over the first rib, underneath the pectoralis myotendon and through the axilla. In addition, give consideration to the potential existence of a relevant cervical rib or other structural anomaly in the region.



Scalenes – in this area adverse tension can develop from anomalous muscular or fibrous slips of tissue, a cervical rib, an abnormal course of the trunks, and/or adaptive shortening from postural habit, disuse and imbalance. This can include an effect upon the dorsal

scapular nerve (C5) as it passes between the anterior and medial scalene muscles towards innervation of the rhomboids, as well as the distal course through the plexus.

Between 1st Rib & Clavicle – in this area adverse tension can develop from anomalous muscular or fibrous slips of tissue, and/or adaptive shortening from postural habit, disuse and imbalance.



Underneath Pectoralis Myo-Tendon – in this area adverse tension can develop from anomalous muscular or fibrous slips of tissue, and/or adaptive shortening (specifically affecting the pectoralis minor) from postural habit, disuse and imbalance.



Axilla - in this area adverse tension can develop from anomalous muscular or fibrous slips of tissue (especially affecting the latissimus dorsi and/or pectoralis major; i.e. the muscular arch of the axilla), and/or adaptive shortening from postural habit, disuse and imbalance.

Two Peripheral Entrapment Neuropathies

Suprascapular Nerve – entrapment can occur as the nerve passes through the suprascapular foramen. The nerve is derived from the upper trunk of the brachial plexus (Erb's point) that is formed by the roots of C5 and C6. The nerve provides motor supply to the supraspinatus and infraspinatus muscles, and sensory supply to the joint capsule, and the AC-joint.

Pain is roughly localized to the posterior and lateral aspects of the shoulder (there is no sensory distribution to the skin), and if there is a significant traction component to the upper trunk there can also be pain down the radial nerve axis and can be tender to its division in the common extensor group. Atrophy, if present, affect the supraspinatus and infraspinatus muscles.

Dorsal Scapular Nerve – entrapment can occur as it passes through the scalene medius. The nerve is derived from the distal portion of the C5 root just before it joins with C6 to form the upper trunk. The nerve provides motor supply to the rhomboids (major and minor) and partial supply to the levator scapula. There is no sensory component to the skin.

Pain is usually felt in the scapular region, and there can be atrophy of the rhomboids and possibly the levator. Due to the relationship to the upper trunk, it is possible to have referral of pain along the radial nerve or C5, C6 levels.

Pain Mechanisms

The IASP (1979) definition of pain is; “ pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage. “ This definition illustrates the subjective and complex nature of the concept.

The Duffy-Rath System© requires that the clinician have a broad appreciation for pain concepts. We target our clinical assessment process towards an understanding of the patient's symptoms,

and the impact they have on function ability. We must be certain to separate the concepts of nociception from the broader concept of pain and the individual's response to pain (suffering, pain and illness behaviors etc.) during this clinical assessment and treatment process. If we do not, we lose the focus of our ability to understand the clinical presentation and the potential remedy to the situation.

Nociception – this is the term used to describe the activation of the nociceptive receptor system. This activation occurs in response to a sufficient amount of mechanical deformation of the connective tissues (distortion, distention, disruption), the accumulation of adequate amounts of chemical irritants (inflammation, infection), or a significant enough change in temperature (excessive cold or heat).

Pain, suffering and illness behavior – this involves the patient's affective and motivational responses to the experience. This includes a complex range of considerations, possibilities and influences which are socially and psychologically generated or influenced. There is an abundance of literature that demonstrates that it is the patient's response to the spinal disorder and not the spinal disorder itself that is more predictive of the long-term clinical course and consequence. Many chronic, disabling spinal pain conditions require a comprehensive, multi-disciplinary approach to patient management.

- **Neuropathic pain** - pain initiated or caused by a primary lesion or dysfunction in the nervous system. It can be primarily peripheral or central in origin, and can be acute or chronic.
- **Allodynia** – pain due to stimulus that does not normally provoke pain.
- **Hyperpathia** – a painful syndrome characterized by an abnormally painful reaction to a stimulus, especially a repetitive stimulus, as well as an increased threshold.

We are proponents for approaching spine pain disorders in accordance with the “Bio-Psychosocial Model’ of Waddell. In attempt to hasten the time of recovery, and to prevent recurrence or progression of the same disorder, we ultimately require the patient to make a behavioral change. This behavioral change inherently involves cognitive, psychological and social considerations. As physical therapists’, our skill and orientation is bio-mechanical (kinesiological). That is why we refer to our system as a bio-mechanically based, behavioral approach. We determine what positions, movements and activities affect the patient's condition for the better and worse. Then educate and train the patient to fight back against the problem through a change in habit and behavior, empowered by understanding.

III. Basic History & Examination

Step one in the clinical assessment process is the history and basic examination. This identifies the patient's relevant signs and symptoms (RSSx) that the treatment strategy attempts to resolve, sets the functional goals, and establishes the therapeutic rapport with the patient.

History-Taking Process

The development of effective communication and interview skills is critical to the Duffy-Rath System©. The initial interview process is the first step to understanding the patient's disorder, and the initiation of patient educating and training. At the end of the interview you should have an expectation for the physical examination, an understanding of the relevant biomechanical factors in the patient's lifestyle, and you are beginning to formulate a plan for the search of 'Tools to Fight Back®' (TTFB). The response patterns that emerge during the interview guide and influence the clinical process. Your ability to remain disciplined and focused, yet pleasant and therapeutic, during this process is critical to success. An effective history is an educational experience for both the patient and clinician.

Overview of the Duffy-Rath History-Process

<p>Patient Enters Office</p>	<ul style="list-style-type: none"> • Completes patient information sheet (demographics, billing, medical/surgical history, medications, cautions & contraindications). • Patient completes Duffy-Rath Questionnaire. • Patient observed.
<p>Patient Enters Examination & Treatment Room (When possible, patient should sit unsupported on the treatment table to expose sitting habit.)</p>	<ul style="list-style-type: none"> • Greeting and explanation. • Review referral. • Review patient information (begin to identify and/or rule-out cautions and contraindications). • Take history • Establish functional goals. • Begin to formulate a response expectation and an appropriate strategy to search for TTFB (after the basic examination).

Be pleasant and let your interest in helping to solve the problem shine through. But, remain focused and disciplined to the process so that you obtain accurate and relevant information. Make certain that the patient understands the questions, and answers the question that has been asked. This means you have to understand each question and develop the communication skills to perform the interview exceptionally well.

Key History Information for Sorting-out Cervico-brachial Syndrome

Onset Information – there are 2 components to this question; first establish when this episode started (i.e. date of onset), and then how it started (mechanism of onset).

Date of Onset – this will be an exact date (mo/day/year) or an estimated date (mo/year). Once the date of onset has been established can be categorized as: acute (less than 1 week), subacute (1 – 7 weeks), early chronic (>7 <26 weeks) and late chronic (>26 weeks).

Mechanism of Onset – this can be divided into 4 basic groups: no one incident or event (NIE), an incident related to a normal ADL (Incident-A), an unguarded, unexpected, sudden biomechanical component of force with a normal ADL (Incident-B), and a high velocity, high magnitude accident (Trauma). Once the mechanism has been established, try to identify the relevant biomechanical and physiological factors associated with the onset.

Mechanism of Onset for Spinal Disorders of Patient's Referred to DRPT (Consecutive Case Series; Rath)							
Category	NIE	Incident Type A	Incident Type B	Trauma	Not Known	Totals	Study Population (Less Unknown & Other)
Overall	690	345	128	158	10	1331	1316
Population %	52.4	26.2	9.7	12.0	N/A	N/A	100
Work-related	462	295	109	103	6	975	967
Group %	47.8	30.5	11.3	10.7	N/A	N/A	100
Population %	35.1	22.4	11.2	7.8	N/A	N/A	73.6
Not Work-related	228	50	19	55	4	356	349
Group %	65.3	14.3	5.4	15.8	N/A	N/A	100
Population %	17.3	3.8	1.4	4.2	N/A	N/A	26.7
Spine Sub-total:	354	217	37	43	2	653	651
Group %	54.4	33.3	5.7	6.6	N/A	N/A	100
Population %	26.9	16.5	2.8	3.3	N/A	N/A	49.5

Comments: Trauma as a mechanism of onset increases the likelihood of multiple mechanical problems simultaneously affecting the patient's ADL. This requires great discipline in the history to recognize the different behaviors of the various pain/symptom patterns. However once recognized and established the rest of the examination and treatment process proceeds much more easily.

Chronicity increases the likelihood of adaptive shortening from disuse, some of which may have been pre-morbid, and the consequences of fibrous repair of the tissue damage as critical factors in the clinical presentation and functional difficulties specific to the patient.

Symptom Location - the most important information is obtained from symptom location at onset, and the current symptom location. At onset provides information about likely mechanics when there was no incident or event and in all cases narrows the possibility of the likely source(s) of the symptoms.

The current symptoms are the critical issue regarding treatment as these are the symptoms you are attempting to affect. Identify the most significant (predominate) part of the symptom pattern (i.e. Neck verses arm etc.), and a general description of the symptoms (i.e. pain, aching, sharp, dull, numbness, tingling etc).

Symptom Frequency – there are two basic groups of responses; constant or intermittent. These groups are divided further into two groups; mechanical and non-mechanical constant, and stable and unstable intermittent. Be certain to distinguish the frequency of each of the differing symptom patterns; e.g. head vs. neck, vs. scapula/shoulder vs. arm etc.

Constant symptoms need to be assessed and treated carefully. Meticulous determination of the presence or absence of mechanical behavior (increases and decreases with ADL) is critical, as well as the distinction between symptoms that are an expression of nociception and those that are not. Constant symptoms that are non-mechanical in behavior required further medical evaluation and diagnosis, as many of these patients should not be receiving physical therapy.

Intermittent symptoms that are produced with ADL, but do not progress or worsen (i.e. have no lasting consequence) are stable and mechanical. Intermittent symptoms that progress, worsen and have functional consequences (they last when the ADL that produced them has stopped) frequently have a combination of mechanical and inflammatory/(biochemical) response that need to be considered, and treatment should proceed cautiously.

Symptom Behavior (Current) - this is a critical and unique section of the history-taking. This line of questioning addresses the presence or absence of mechanical patterns of symptom behavior, identifies what ADL are interfered with by the disorder, provides insight into the patient's objectivity, shows your determination to get to root causes of the problem and is very educational. Explain the process to the patient before you begin, and make sure they are describing the current/recent behavior of their symptoms.

Term	Definition
Better	The activity/position reduces or abolishes symptoms that are present.
Worse	The activity/position produces symptoms that were not present, or increases those that were present.
Varies	The effect upon the symptoms varies. Have the patient explain this and/or ask more questions to learn more. This is a common and very important response as you and the patient will learn a great deal of relevant information.
No Effect (NE)	If symptoms are present the activity/position will not increase or decrease them. If symptoms are not present, the activity/position does not produce any effect.
Don't Know/Not Sure (??)	Haven't performed the activity/position recently, have not paid attention or am not sure.

Four groups of symptom behavior questions:

- **The effect of specific ADL on the symptoms** – this is the bulk of the questioning. Identify the behavior of the symptoms with neck/upper back movements, positions and activities verses those involving the upper limb. Be certain, if there are multiple pattern patterns to isolate the response to each.
- **Effect of time period of the day** – this is a more general line of questioning, looking to see if the symptoms are at the best or worst at certain time periods, or is it a product of specific activities/positions regardless of day time (i.e. varies according to the activity and not the time of day).
- **Val Salva's** – pain upon coughing, sneezing or straining is not pathognomic, but highly associated with discal pathology. Pain and difficulty taking a deep breath is strongly associated with a thoracic disorder; i.e. a mechanical problem with extension.
- **Other** – always give the patient an opportunity to provide more information than the structured process and approach may not have uncovered. Many 'pearls of information' are uncovered by providing the patient with this opportunity.

Other History Information

1. Diagnostic Tests: Determine what diagnostic tests and procedures have been performed this episode. Has the radiographic analysis been complete, or is more information required. Ask the patient to report the results, and compare this to a review of the official diagnostic reports.

Look for the impact that of the results of these tests and the explanations provided have had upon the patient's perception of the problem.

2. Previous History & Treatment: Determine if this is a recurrent problem or not. If so, how frequent and is this episode similar to previous ones? What treatment have they had in the past, and what was their response to these treatments?

5. Accidents/Traumas: Ask about significant accidents or trauma that could relate to the diagnosis and problem, and/or influence treatment.

6. Other Questions: The very last question of the history, prior to setting functional goals, is to ask if there is anything else to report, or has been overlooked in the history thus far.

Setting Functional Goals

At the end of the history you and the patient will need to establish 2 – 3 functional (activity) goals for treatment. These should be normal ADL tasks that the patient's problem has interfered with, or he/she are currently unable to perform. These are identified during the assessment of the current behavior of the symptoms. Once the function goals are established, eliminating or decreasing interference with these ADL tasks becomes the goal of the treatment program, and a measure of its success.

Overview of the Basic Examination

The physical examination process identifies the presence or absence of relevant clinical signs. The signs identified will be either non-specific or specific, and either directly or indirectly relevant to symptom generation and the functional/ADL problems the patient is reporting.

Disciplined and properly performed physical examinations procedures are fundamental clinical skills that every clinician needs to master, and includes the following 5 components:

- | | |
|-----------|-------------------------------|
| 1. | Observation/Inspection |
| 2. | Neurologic screening |
| 3. | Motion Assessment |
| 4. | Contraction Assessment |
| 5. | Auxiliary Tests |

Basic Examination of the Upper Back & Lower Neck

The majority of patients with upper back and lower neck pain will have a disorder emanating anywhere from C5 down to T2, with either side of C6 having the highest incidence.

The relevance of your examination findings will be determined by their effect upon the patient's symptoms (i.e. the symptoms identified in the history) and the impact on physical function. Examination procedures that provoke or relieve the symptoms are stated to have, '**direct relevance**'. Examination findings that do not directly affect the symptoms, but can be connected

specifically to the patient's difficulties performing ADL (i.e. meet the physical or load demands of their lifestyle) are stated to have, '**indirect relevance**'.

The following is an overview of common symptom patterns encountered in clinical practice with upper back and lower neck disorders.

Symptom Patterns: the most common pattern is for symptoms to be felt in the area of the C/T junction. Central disorders will cause central pain, or symmetrical patterns. Asymmetrical disorders will cause symptoms that are more on one side than the other, and unilateral disorders will cause symptoms that are off mid-line to the side of the disorder. When the origin of the pain is higher in the spine, the pain is usually felt higher. However, referred pain is common and this can be misleading.

The scapula and shoulder region is a common area of referred pain from the cervical spine. The lower the cervical segment, the lower the in the scapular region the symptoms are felt (Cloward 1959). Therefore, pain in this region could be emanating from the cervical or thoracic spine, the ribs, the upper back musculature, or the shoulder girdle. Since the cervical plexus does not innervate the upper limb, symptoms in this region may be associated with the upper cervical spine and therefore could include neurologic or dural tension signs. Always remain aware of this in the process of your basic examination. In addition, these symptoms can also be associated with a peripheral entrapment neuropathy; e.g. dorsal scapular nerve, suprascapular nerve etc.

Radiation of symptoms into the upper arm are usually nonspecific; i.e. not accompanied by neurologic signs and not specific to a dermatome. However, they can be associated with a C 5 radiculopathy (look for corresponding signs) or could be coming from the shoulder complex. These can be a product of adverse dural tension, and this would be confirmed by specific dural tension testing. .

Symptoms extending below the elbow have the greatest probability of association with specific root pathology. As always, look for a correlation with neurologic findings and specific dermatomes. Nonspecific radiation could be referred from any of the proximal structures and the entire arm can be associated with non-organic patterns. Color and temperature changes are associated with circulatory entrapment or flow abnormalities, and with autonomic dysfunction.

Remember that your assessment needs to include the lower limbs and distal function, as the cord can be involved with cervical and/or thoracic lesions. Ask questions about paresthesia in the feet, ataxia and gait disturbances, loss of control over bowel and bladder function etc. Your neurologic examination will investigate for cord signs.

Always keep in mind the possibility that the patient's symptoms are related to a medical condition or disease process, and not a MSD. This is usually associated with a lack of mechanical symptom behavior in the history, and minimal to no relevant findings in the basic orthopaedic examination.

When asking the patient about the symptoms, make sure that you phrase your questions in a way that does not limit or lead the patient's answers. .

1. **Inspection/Observation of the Upper Back/Neck-** systematically inspect the neck, upper back, shoulders and upper limbs for signs of trauma, anomaly or trophic disturbances. Postural assessment starts with the back, shoulders, chest and proceeds to the head/neck. Look for the acute deformities of ‘wry’ neck or acute torticollis, or acute flexion. A ‘dowager’s hump’ is a common finding, especially in older patients and should not be confused with an acute deformity; i.e. you need to distinguish acute deformity from adaptive or degenerative change, normal structural asymmetry and functional adaptations.

2. **Neurologic screening** – perform a motor and sensory examination of the upper limb(s), test DTR (all four limbs PRN), and test the Babinsky (look for sustained clonus and perform the Hoffman Test if suspicious of cord signs).

3. **Motion assessment** – motion assessment of the lower neck and upper back has to be tested from a position of axial alignment. A relevant loss of normal motion is the most common examination sign we are attempting to effect in the basic examination.

Duffy-Rath Spine Motion Loss Table© Willing apprehensive unwilling inconsistent

Motion Tested	Segmental Loss (0– 10)			Limiting (ER) Response			PDM	Comment
	C	T	L	Cervical	Thoracic	Lumbar		
Flexion								
Extension								
R-Sidebend								
L-Sidebend								
R-Rotation								
L-Rotation								

You need to answer the follow series of questions regarding the patient’s movement ability:

- Is there any loss of motion in the neck or upper back?
- If there is loss, is it within the spinal segments, or in the external soft tissues?
- If there is loss of motion (internal and/or external), is it relevant to the patient’s clinical condition?

Many times the only way to determine whether or not there is a segmental loss is to remove all of the tension in the extra-articular, multi-joint tissues. This may require you to have the patient lie down and/or insure that the movement is performed passively for an accurate determination.

If the mechanical effect of these tissues is eliminated and there is still a loss of motion with a relevant symptom response, the disorder lies within the motion segments. This analysis can be augmented by performing a ‘spring test’, static or dynamic at each of the spinal levels.

Spring Testing

This is used, only when necessary, to isolate/focus the mechanical test to the motion segments in order to identify or rule-out intra-segmental dysfunction. The classic procedure is performed prone with a P-A mobilization. However this is limited to provoking a symptom or sign response with end range extension only. This is why I incorporate the concept of ‘mobilization with movement’ (Mulligan) to the spring test. This dynamic procedure has the potential to provide more relevant information about intra-segmental dysfunction, as it can be performed in all directions of motion.

Upper Limb Tension Testing

If the only time there is a relevant (symptom reproduction) loss of motion is when there is tension in the external structures, then the problem lies outside of the segment.

Adverse neural tension is a common problem with cervico-brachial syndromes and frequently the main target of treatment. You need to have a system that attempts to determine the site of the adverse tension; i.e. foramen, thoracic outlet or in the arm (this workshop focuses on the 2 proximal sites only).

Biomechanical Considerations for Upper Limb Tension Testing	
<i>Add Tension</i>	<i>Remove Tension</i>
<ul style="list-style-type: none"> • Side-bend away +/- flexion or protrusion (extension can too) • Shoulder depression, Abduction, external rotation, hyper-extension • Elbow extension, supination, wrist & finger extension 	<ul style="list-style-type: none"> • Side-bend towards +/- MR extension or ipsilateral rotation • Shoulder elevation, adduction, internal rotation • Elbow flexion, forearm pronation, wrist and finger flexion

The Assessment Process for Adverse Upper Limb Tension: when you have been able identify the relevance of the ULTT to patient’s symptoms, signs and functional difficulties you to try to figure how where the problem lies. The following process will help you to sort out the most probable location of the problem:

Step One: Motion loss assessment with tension in external multi-joint structures removed.

- If motion is full and symptom free the problem does not lie within the intervertebral disc, lateral interbody or the z-joint complex.
- If motion is not full and affects the relevant symptoms, there is a problem inside of the motion segment and this should be addressed first.
- If the motion is full, but movements that close down the I-V foramen on the affected side reproduce the referred/radiating symptoms there is a space occupying problem within the foramen.

Step Two: ULTT

- Patient is positioned supine close to edge of table on the involved side, pillow under head and in neutral.
- Apply and sustain depression to the shoulder girdle.

- Place the GHJ into external rotation, slight extension.
- Extend the elbow and supinate the forearm (initially I don't add wrist and finger extension unless the test is negative).
- Maintain all of the above and slowly abduct the arm until 'the' symptoms are reproduced (the degree of abduction is measured).

Step Three: ULTT + ipsilateral lateral flexion.

- Maintaining the position of ULT that reproduced 'the' symptoms, have the patient side bend their head ipsilateral (the patient usually has to be trained how to side bend, they will invariably rotate).
- If the symptoms are immediately lessened or abolished (you will usually feel a reduction in tension), this is the first evidence of a length-tension problem in the upper limb system.
- If the symptoms are not affected, this is your first evidence that the tension lies distal to the neck and proximal thoracic outlet.
- If the symptoms are increased, this is your first evidence of an entrapment within the foramen or thoracic outlet.

Step Four: ULTT + contralateral lateral flexion.

- Maintaining the position of ULT that reproduced 'the' symptoms, have the patient side bend their head contralateral (the patient usually has to be trained how to side bend, they will invariably rotate).
- If the symptoms are increased (and the available ROM decreased), this is further evidence of abnormal tension in the upper limb system.
- If the symptoms are decreased, this is further evidence of a space occupying problem within the foramen.
- If the symptoms are not affected, this is evidence that the problem does not lie within the upper limb system.

Step Five: Lateral Flexion with ULT Removed.

- Remove tension within the upper limb system (shoulder elevation +/- protraction, adduction, internal rotation, elbow flexion etc. = the hug position).
- If the patient can now side bend contralateral through a much greater ROM with no reproduction of symptoms, and ipsilateral side bending has no effect, this confirms that the problem is within the upper limb system.
- If the patient continues to reproduce symptoms with contralateral or ipsilateral side bending, there is a problem within the segments.

4. Contraction Testing (PRN) - with the spine segments in a neutral position, perform an isometric test of the neck and/or upper back muscles to see if 'the symptoms' are reproduced. Muscle strain is more likely in the neck and upper back than in the lower back, especially when the mechanism of onset involves large or unusual mechanical forces suddenly applied, or

repetitiously performed. This should correspond to a change in symptom and sign response with active and passive movement, especially when tension in the external structures is altered.

MMT is also performed to determine patterns of strength and weakness of key muscles that may be relevant to the patient's functional difficulties. I frequently do this on the follow-up visits, as the initial visit is focused towards understanding and controlling the signs that have direct relevance. The basic strength and physical demand ability of the patient becomes important for the strategic strength and conditioning program and ultimately for concepts of prevention.

5. Auxiliary Tests - by definition, auxiliary tests are performed only when necessary. These procedures are used to obtain specific clinical information that is not obtained with the standard examination procedures. The following are some of the common auxiliary tests:

- **Vertebral-Basilar Artery Testing (VBI)** - The intent is to determine if any of the symptoms or signs associated with VBI are reproduced with a sustained position (up to 30 sec) that could reduce the blood flow through these vessels (end range rotation and/or extension). Test the patient by gently placing the head/neck into end range rotation (L&R) and extension. Sustain for up to 30 seconds to see if any signs or symptoms appear (you must be able to achieve end range to properly administer this test).

Possible Symptoms	Possible Signs
Dizziness, disorientation, headache (atypical), diplopia, vertigo, tinnitus, blurred vision.....	Dysphagia, dysarthria, nystagmus, drop-attacks, incontinency, Horner's Syndrome, vomiting (atypical).....

- **Shoulder Assessment** – this includes PROM in all directions (may be best performed supine to remove neural tension), contraction testing in joint neutral and auxiliary tests (PRN).

- **Circulatory Assessment** – check pulses and evaluate for any signs of circulatory changes in the upper limb with the various mechanical tests performed, especially the ULTT.

6. Function testing – ultimately the ability of the patient to eliminate the interference of the symptoms to their normal ADL function has to be assessed. This can be evaluated formally, informally or by a combination. The patient can be observed performing a task (reach, lift, carry, push, pull, throw etc.) and the symptom response assessed before and after treatment. The reassessment interview at each visit includes several measures of the patient's reported change in function, and whether or not they have returned to activities successfully. The DRQ measures their self-reported ability and can be compared throughout the course of treatment. And specific quantitative measures (FCE) can be performed.

Identification of the RSSx

At the conclusion of the history and basic examination you have an understanding of the most relevant subjective and objective findings. Your initial treatment strategy will be determined by your ability to control these symptoms and signs. We call these the relevant signs and symptoms (RSSx).

The Relevant Symptoms - there will be four basic symptom responses to assess for change & control:

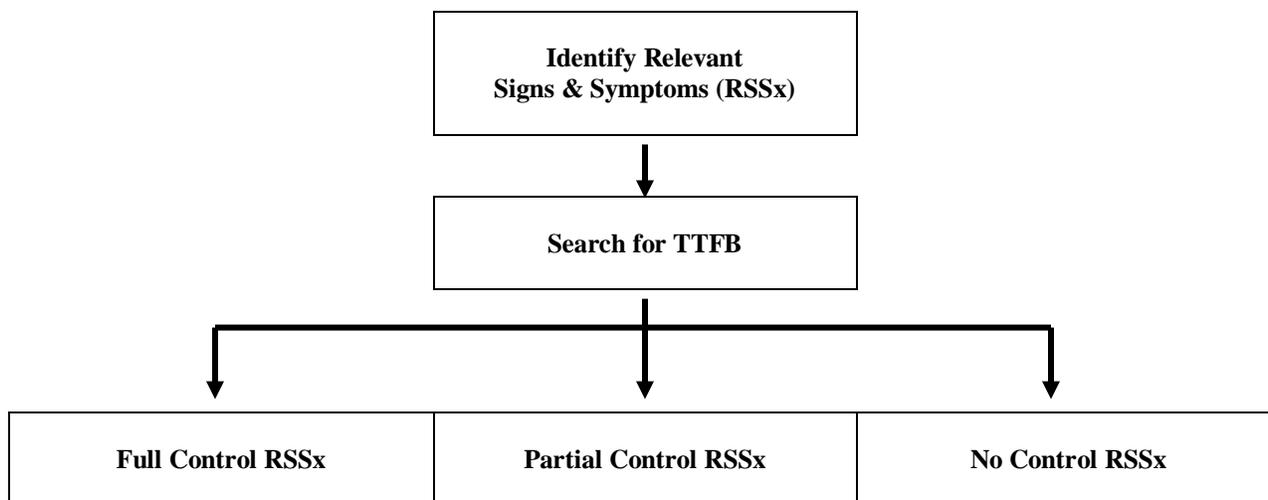
- **Location** – the intent is to reduce the size of the symptom area consistent with a reduction of pathology when applicable.
- **Intensity** – the intent is to reduce the severity of the symptoms.
- **Frequency** – the intent is to reduce the amount of time the patient feels the symptoms.
- **Behavior** – the intent is to reduce the interference of the symptoms with ADL.

The Relevant Signs = these are the observable, measurable clinical findings that have been found to be relevant to ‘the’ symptoms, the disorder and the patient’s lifestyle. There are two basic groups of relevant signs:

- **Examination Signs** –these are the neurologic signs, the motion loss, the contraction or auxiliary findings that were relevant to the patient’s symptoms and disorder. The intent will be to reduce these findings, especially as they relate to ADL.
- **Function Signs** – these are the ADL and physical measures that have become interfered with, or are a direct measure of the individual’s ability to meet the physical demands of the ADL.

IV. Searching for TTFB®, Conclusions & Treatment Strategies

The search for TTFB® is a shared investigation by the therapist and patient to determine the best treatment strategy by assessing how much control over the RSSx can be immediately achieved. Make sure the patient is well informed as to the intent and method of your search. The starting point to this search should follow conservative guidelines.



How you begin this search will be dependent on what the RSSx are, how they behave, and how the patient is reacting to their problem. As a general rule, the symptom response is assessed first,

the sign response second and the functional response last. The following are guidelines for the search:

Assess the Symptom Response First

When Symptoms are Constant – choose a position or gentle (mid-range) procedure that has the greatest likelihood to reduce or abolish the symptoms. The goal is to determine if the pain can be reduced, or temporarily abolished, and to educate and train the patient about the importance of controlling mechanical aggravating factors during the resolution of the problem.

Example of Procedures
<ul style="list-style-type: none"> • Posture correction (axial alignment) sitting +/- supports • Posture correction lying with pillows +/- supports • Biomechanical training with basic position changes & ADL • Remove Upper Limb Tension sitting and/or lying • Gentle (grade 1) joint mobilization for segmental motion loss • Modalities PRN

When Symptoms are Unstable Intermittent – choose a position or gentle procedure that is least likely to aggravate the symptoms, and most likely to begin to gain control over the RSSx. Provided the symptoms response is favorable, begin the attempt to reduce the most relevant sign, but very carefully.

Example of Procedures
<ul style="list-style-type: none"> • Same as with constant symptoms • Gentle, but potentially progressive joint mobilization for segmental loss

When Symptoms are Stable Intermittent – choose a position, movement or procedure that directly addresses the most relevant sign; i.e. challenge the sign. Closely monitor the response to determine if the symptoms are really stable, followed by the determination of the stability of the sign. If there are no directly relevant signs (a stage 1 disorder) our treatment is dependent upon having the patient experience control over the production and then resolution of their symptoms with biomechanical control procedures.

Example of Procedures
<ul style="list-style-type: none"> • Sustained end range position • Repeated end range movement joint, progressing to overpressure when appropriate • Repeated end range movement extra-segmental, progressing to overpressure when appropriate • Activity/function testing and analysis • Combined performance techniques • Joint mobilization • Soft-tissue mobilization

When Symptoms are Non-organic – do not try to eliminate symptoms. Begin treatment with education and training in biomechanical control during ADL function (24/7). This becomes the foundation for the graded exercise program that will be implemented to achieve the function

goals for treatment. This group requires a considerable amount of ongoing support and encouragement.

Example of Procedures
<ul style="list-style-type: none"> • Posture correction (axial alignment) sitting +/- supports • Posture correction lying with pillows +/- supports • Biomechanical training with basic position changes & ADL

When Trauma is the Mechanism of Onset – first, be certain that the patient has been adequately worked-up to rule-out fracture, subluxation etc. If there are neurologic signs proceed very cautiously and in close communication with the medical physician. In the first 3 weeks keep your procedures in mid-range and gentle. Effective postural/ergonomic instruction and training will facilitate a more rapid recovery from the injury. Between weeks 3 – 6 the procedures can progress to end range, avoiding overpressure until the symptoms are proven to be stable for 3 – 5 days in succession. Keep the patient as active as possible throughout the recovery, with tolerance and response (commonsense) as the guideline. Beyond 6 weeks, if not already achieved, implement a strategic plan to regain normal activity tolerance.

Example of Procedures
<ul style="list-style-type: none"> • Same as constant

When there are neurologic signs – the presence of neurologic signs indicates the severity of the patient's condition. You will need to meticulously assess and reassess these signs throughout the course of treatment. When these signs have recently developed they are most likely to be affected by treatment for the better or worse. When they have been present for a chronic time period, they are more likely to be static and unaffected by treatment. Start with posture/ergonomic tools, and proceed slowly and cautiously. Stop treatment and contact the medical physician at any time these signs are found (or suspected) to have progressed.

Example of Procedures
<ul style="list-style-type: none"> • Careful exploration according to state and response of the symptoms with meticulous assessment of the signs; i.e. as with constant symptoms.

When in doubt – posture/ergonomic instruction and training is always a safe place to start, but if there is suspicion of more serious pathology or disease, contact the medical physician before implementing any specific treatment strategy.

Assess Sign Response Second

Once a favorable symptom response has been achieved, the significance of this is determined by the concomitant degree of change in the relevant signs and stability of any improvements.

When there were no signs – this is a stage 1 disorder and our postural/ergonomic strategy is implemented, therefore it is symptom response only that drives the treatment. As mentioned above, having the patient experience control over production and resolution of the symptoms is critical to short and long-term efficacy.

When the relevant sign is a loss of intra-segmental motion – this is a stage 2 or 3 disorder and the target is to restore normal segmental motion. This includes a normal response to end range loading and the improvements remain better in upright ADL.

When the relevant sign is a loss of extra-segmental extensibility – this is a stage 2 or 3 disorder and the target is to restore a normal end-range response to stretching and a range of motion that is adequate for the patient’s lifestyle.

When the relevant sign is neurologic – this is a stage 3 disorder and meticulous assessment and management is required. You should continuously exam the patient for a change; strength, reflex or cutaneous sensibility. Rapid improvement suggests that the sign was soft; i.e. no neuronal damage. Deterioration indicates an expansion or worsening of the condition and immediate attention to the medical physician or surgeon is warranted, especially if any cord signs emerge.

A lack of any change suggests that the sign is older, established and unlikely to be affected by treatment; i.e. will improve to potential over time. Do not rush to this conclusion for you may be wrong. Constant reassessment over several weeks of treatment will confirm or reject your conclusions in this regard.

When the relevant sign is a loss of activity tolerance – when there are no specific or significant examination signs and/or they are inconsistent and unreliable, but the patient is unable to return to their normal ADL (work, home, play) because of their symptoms. The sole target for the treatment becomes the development of a strategy to return to function and regain activity-tolerance.

Assess Function Response Last

Once you have found procedures that have an appropriate affect upon the symptoms and signs, the significance of these changes is measured by the improvement (or lack of improvement) in the patient’s ability to perform ADL tasks. This will be assessed multiple ways, with the following options:

1. **Observation & reporting** – compared observed change in the patient’s ability to perform an ADL task before and after the treatment, obtaining information about symptom response change.
2. **Self-reported assessment** – through the use of functional and disability questionnaires and structured interviews you can obtain information about perceived change in function.
3. **Measured** – when possible and appropriate, a specific task or physical performance can be objectively measured; i.e. ROM, strength, functional capacity tests etc.
4. **Occupational** – did the patient go back to work, if so to full or restricted duty?

5. **Recreational** – did the patient return to their normal recreational and athletic activities?

Duffy-Rath Musculoskeletal Traffic-light Tool©	
The response of the patient's relevant symptoms and signs are continuously and meticulously monitored as you search for the TTFB. The ability to consistently decrease or abolish (i.e. control) these clinical/functional findings will identify the TTFB and determine the utility. In 1985 Wayne and Jean developed the 'Musculoskeletal Traffic-light Tool' as a guideline for assessing the patient's response.	
RED LIGHT (STOP)	Symptom pattern is expanding Symptoms are progressively increasing in response to a consistent or diminishing amount of loading. The increase or production of symptoms persists after the load is removed. There is the production or increase of relevant clinical signs (movement loss, neural tension, neurologic, function intolerance)
YELLOW LIGHT (PROCEED CAUTIOUSLY)	Symptoms are being produced or increased, but are not progressive, are not persisting after the load is removed and are not associated with a production or increase of relevant signs. Signs and symptoms are reduced or eliminated with the application of load, but this improvement does not last.
GREEN LIGHT (GO)	Symptoms are contracting, decreasing or are eliminated. Relevant clinical signs are lessening or eliminated. The improvement in symptoms and signs lasts after the load is removed in weight bearing and with functional reassessment.

Assessment Conclusions & Treatment Strategy

The purpose of the history and examination is to come to a conclusion that enables you to determine:

1. Is physical treatment appropriate?
2. If yes, what is the most appropriate treatment strategy?
3. What are the expectations of response to this strategy?
4. How will the response to treatment be measured?

The Duffy-Rath System© establishes 2 groups of conclusions from the examination that guides the treatment and education/training strategy: 1) response group and 2) stage of disorder.

1. Response Group – this conclusion guides the choice and implementation of the initial treatment strategy and the formulation of clinical expectations. It will strongly influence the prediction of outcome and utilization of your physical therapy service.

- **Rapid** – this group has demonstrated the ability to eliminate relevant signs and symptoms with postural/biomechanical instructions, self-exercise, manual therapy and/or certain biomechanical procedures. The clinical improvements are stable and lasting when functionally tested.
- **Static** – this group does not exhibit the ability to change rapidly. If the relevant symptoms can be reproduced, they do not worsen with repeated or progressive testing. If the relevant

signs or symptoms are improved, the improvement is partial and not lasting. The condition is stable, but not rapidly changeable, or does not remain better to a significant degree when functionally tested. .

- **Adverse** - this group needs to be managed carefully and meticulously. Their physical examination findings and response to clinical assessment (combined with their current history) indicates that there is extensive pathology and/or an active inflammatory response present. These patients demonstrate the ability to worsen with physical examination, and no rapid or substantial ability to improve the relevant signs and symptoms. This group can be difficult to predict outcome and utilization initially. Many will require help from the medical physician to control the inflammation (injections, medications etc.) and/or perform further diagnostic studies.
- **Non-organic** – this group demonstrates objective evidence of non-organic findings. Waddell’s signs and symptom’s assessment have a cluster of positive findings, pain drawings do not follow anatomic patterns and/or exhibit distress, VAS ratings of pain and disability are disproportionately high. This group will be more difficult to predict and treatment is invariably longer than average when a good/excellent outcome is achieved. Treatment approach will have to be oriented to function, and multi-disciplinary support is often required.
- **Other** – this provides another category for those patients that do not fit into the previous groups. This group does not demonstrate conclusive evidence of a biomechanical response of the signs and symptoms, or the physical examination procedures have no consistent effect on the signs or symptoms. In order to tick this group off, the patient must not present with non-organic, inappropriate pain behaviors. This group represents caution or contraindication to physical therapy (dependent upon previous diagnostic evaluation and communication with the referring physician).

2. Stage of Disorder – this conclusion identifies the severity of the disorder from a structural perspective. The stage progresses as the condition worsens, and reduces as the condition resolves. Early intervention is important for the prevention of progression of both current and future episodes. This concept is crucial for the education and training strategy for musculoskeletal self-efficacy in the Duffy-Rath System©.

Stage I (warning signal stage) – stable intermittent symptoms only, no physical examination signs relevant to the patient’s condition. Symptoms are a fatigue response in one or more of the musculoskeletal tissues/structures.

Potential Source of Symptoms	
Passive Support Structures – due to mechanical fatigue from sustained and repeated end range loading.	Dynamic Support Structures – due to physiological fatigue from sustained or repeated contraction in response to physical demand.

Stage II (non-specific disorder stage) – symptoms become less stable and /or expand, and non-specific physical examination signs begin to appear; i.e. there is loss of motion, but there are no neurologic signs, or evidence of tendon, cartilage or ligament rupture/laxity etc.

Common/Potential Source of Symptoms & Non-specific Signs	
Symptoms + Loss of Segmental Motion <ul style="list-style-type: none"> • I-V disc displacement • Zygapophyseal joint derangement 	Symptoms + No Segmental Loss of Motion <ul style="list-style-type: none"> • Myofascial strain • Ligament, capsule sprain • Neural mechanical dysfunction

Stage III (pathology stage)– symptoms and signs have progressed and are now consistent with specific pathologies; i.e. evidence of nerve root compression, spinal instability, spondylolisthesis etc. If diagnostic studies have been performed, the findings must correlate to the patient’s relevant signs and symptoms due to the problems associated with specificity of most diagnostic tests.

Common Structural Pathologies		
<u>I-V Disc</u> <ul style="list-style-type: none"> • Annular tear • Disc herniation (protrusion, extrusion and sequestration) 	<u>Stenotic Disorders</u> <ul style="list-style-type: none"> • Congenital &/or acquired • Central or lateral • Osteophytosis • Soft-tissue proliferation • Prolapsed, sequestered intervertebral disc 	<u>Instabilities</u> <ul style="list-style-type: none"> • Degenerative; i.e. annular disruption, capsule and ligamentous, osseous (listhesis). • Traumatic • Congenital anomaly

Nerve Root Tension Signs

There are a number of reasons for the presence of nerve root tension. Therefore a positive SLR, upper limb tension test (ULTT) etc. is not pathognomic for one disorder. A positive root tension sign can be due to:

Intervertebral disc displacement - as the intervertebral disc progressively distorts and displaces, it becomes more likely to mechanically compress the dural coverings. The critical factors involved in the likelihood and degree of compression correlate to; 1) the size of the displacement, 2) the location of the displacement, 3) the size of the neural foramina and the 4) presence of any congenital abnormalities. The greater the compression, or entrapment of the neural structures, the greater the dural tension signs and greater the probability of neurologic signs.

Chemical sensitization – the nerve root complex can become chemically sensitized by chemicals (prostaglandins, phospholipase-2, histamine etc.) that leak into the epidural space secondary to injury and/or degenerative change.

Foraminal narrowing – inadequate space for the exiting neural structures is another reason for dural tension signs. This can be due to degenerative changes, congenital anomaly, iatrogenic causes and structural instability.

Circulatory Stasis – inflammation and circulatory congestion in the central and lateral canals is another source of compression and irritation. This is a primary mechanism of the production of symptoms and signs in neurogenic claudication, but can also occur in response to mechanical lesions involving the disc and/or zygapophyseal joints (especially post-trauma).

Adherence of the nerve root (dura) – the dura can become tethered to the posterior wall of the intervertebral disc (or some other fixed structures in the neural canal) as a result of the repair response to trauma in that region of the spine. It is also possible that the normal elasticity of the neural structures is lost from disuse (adaptive shortening) over prolonged periods of inactivity.

Trauma to the nerve root – the nerve roots have some vulnerability to stretch-injury. This vulnerability is more pronounced in the lower cervical/upper thoracic region because of the large range of movement of the upper limb and the cervical spine laterally.

Intrinsic neural disease - a variety of nervous system pathologies can yield positive dural tension signs. These are outside the realm of this workshop, and are a contraindication to the Duffy-Rath System©.

Not Applicable – the concept 3-stages may not be applicable to the patient’s condition, or the reason they are seeking physical therapy assessment and treatment. **Example:** this applies to patient’s with systemic disease (e.g. rheumatoid arthritis, lupus, gouty arthritis, ankylosing spondylitis etc.), or for any patient that comes for treatment and their diagnosis does not fit into the three stages model for musculoskeletal disorders (multiple sclerosis, CVA etc.).

The Quebec Task Force on Whiplash-Associated Disorders (Spine 20 (8S), 1995): we have used a modification of the classification system developed by the origin Quebec Task Force (Spine 12- 7S, 1987) since its publication. In 1995 the task force published the findings of a multi-disciplinary investigation regarding whiplash-associated disorders (WAD). We found this reassuring, as the suggestions are quite similar to our ‘Three Stages of CTD/RSI Disorders’.

Grade	Clinical Presentation
0 -----	No complaint about the neck No physical signs -----
I	Neck complaint of pain, stiffness or tenderness only No physical signs
II	Neck complaint AND Musculoskeletal signs *
III -----	Neck complaint AND Neurological signs ** -----
IV	Neck complaint AND Fracture or dislocation
* Musculoskeletal signs include decreased ROM and point tenderness. ** Neurological signs include decreased or absent DTR’s, weakness, and sensory deficits. Symptoms and disorders that can be manifested in all grades include deafness, dizziness, tinnitus, headache, memory loss, dysphagia and temporomandibular joint pain. ----- Dotted lines indicate terms of reference of the Task Force.	

Duffy-Rath Treatment Strategies

There are six basic treatment strategies used in attempt to control the RSSx and achieve the functional goals for the individual patient. The following overviews these strategies:

1. Anti-inflammatory - the goal is to convert the pain from constant and easily exacerbated to intermittent and stable. This is achieved through instruction and training of the patient in the most effective mid-range (resting) positions for the tissues/structures involved in the disorder. Treatment can include the use of anti-inflammatory modalities (ice, phono and iontophoresis, electric stimulation etc.) in conjunction with medications prescribed by the medical doctor. However, the focus will be to use physical/biomechanical methods of control. The patient will be advised to remain active to tolerance. Once the condition is stable and the symptoms begin to behave with a mechanical pattern, the treatment will progress cautiously according to the posture/ergonomic, remodeling, reduction or stabilization guidelines.

2. Posture/ergonomic – this treatment plan centers on educating and training the patient in self-management skills that are centered about the TTFB® concept; posture, body mechanics, strategic micro-pauses, opposite movement rule and strategic strength and conditioning. Stage I disorders and many early stage II will utilize this treatment plan. Therefore, how early you are intervening in the development of disorder will influence the frequency of the use of this treatment plan as the sole method of intervention. However, all treatment strategies include the basic components this strategy, for postural/ergonomic training and the development of an individualized ‘TTFB®’ system is the foundation of the Duffy-Rath System©.

3. Reduction – this treatment plan is used for patients in the rapid response group that have a relevant loss of segmental spinal motion (Stage II – III), and you have proven or strongly expect that the loss can be rapidly eliminated and remain better. In the general population of patients seeking health care for an activity-related spine pain disorder, this is the largest group. Remember, that most of these patients transitioned through stage 1 and could have been effectively treated with the posture-ergonomic strategy at an earlier point in time.

- **Phase I** – identify procedures that eliminate the relevant loss of motion and control or eliminate the symptoms. This can be achieved in variety of ways, but ultimately must be lasting and functional to have a significant value.
- **Phase II** – this is the process of maintaining the improvements in signs and symptoms until the condition is stabilized (i.e. can no longer be made worse). This can be the most difficult, and ultimately the most important phase of the treatment plan. This is achieved through the same basic intervention strategy used for posture/ ergonomics (see above).
- **Phase III** – this is the process of reactivating the patient with the intention of returning them to their normal level of activity and function. This recovery of function phase reinforces the importance of balance and activity in the recovery. The ability of the patient to return to normal activity will be the ultimate measurement of the success of the intervention.

4. Remodeling – this is the treatment plan for the static response group. This will occur most frequently with chronic disorders and/or patients with longstanding lifestyle factors that are just starting to cause problems. These will be Stage II or III disorders, but can occasionally involve a Stage I problem. This group is chosen when the patient does not present with any significant behavioral and/or non-organic responses.

The goal with this patient will be to regain normal motion and contraction, and ultimately to restore tolerance to loading and activity. This is the, 'no pain - no gain group'! However, any symptoms that are produced or increased during treatment must not show evidence of causing the condition to deteriorate. This needs to be monitored carefully, especially in the initiation of treatment and when you make treatment progressions. All groups will be trained in appropriate postural, ergonomic and biomechanical procedures. Treatment will conclude with individual prevention training.

5. Stabilization – this treatment plan involves exercise and training of the patient to function with optimal body mechanics, maintaining the spine in a mid-range position. The specific strategy will be individualized to the patient's condition, ability to control relevant symptoms and signs with TTFB and functional goals. Therefore, the program may have an extension, lateral, flexion, combination or neutral bias. This is used for structural and functional instabilities; i.e. those patients that do not remain better in weight bearing and functional loading ADL. The program is centered upon a progression of strength and conditioning exercises that will provide dynamic support to the involved joints and gradually restore the patient's tolerance to load and activity.

6. Function - this treatment plan is used for those patients in the non-organic response group. We do not monitor the symptom responses closely. Rather, we monitor the response of the signs carefully to insure that the condition is not deteriorating. The intent of the treatment is for the patient to successfully return to work and/or activities; i.e. to regain tolerance to positions, movements and activities. We will use the same biomechanical principles as with the postural/ergonomic and the stabilization strategies, but will not pay close attention to symptom reporting. To use this plan effectively it is important that the patient has been thoroughly work-up diagnostically and there are no clear medical/surgical explanations and solutions.

The use of objective measurement tools is very important to the clinical management of this group of patients. Establish a baseline of information regarding pain, perceived function, strength and conditioning. At defined intervals (at least prior to discharge) repeat the same measures and determine the progress. Goals should be set to achieve specific, concrete improvements in physical (functional) capability. This group of patients will need maximal encouragement, and a coordinated, multidisciplinary team approach.

7. Other - this category is for any other treatment plan that does not fall into any of the previous groups.

V. Reassessment, Treatment & Discharge Process

It is relatively easy to examine the patient and come to a conclusion. It is another story to implement a program and then see it through to completion. The success or failure of your intervention is determined in the sequential visits after the initial assessment and treatment.

The objectives and expectations of the reassessment process is to:

- Determine if your initial conclusions were correct and relevant.
- Determine if the treatment plan is correct and as effective as expected.
- Determine if the patient understands his/her role in treatment and the instructions provided.
- Determine if the patient is performing the techniques properly and effectively.
- Determine if the treatment program needs to be progressed.
- Determine the need to plan the patient's discharge.
- Determine any inappropriate changes in the patient's condition.
- Determine the need to refer the patient to a medical physician or specialist.

In the Duffy- Rath System©, the reassessment process is outlined as follows:



Patient Re-enters

- Completes pain drawing, pain ratings and functional questionnaire (again)
- Reassessment Interview
- Self-management Analysis
- Tests/treatment procedures
- Special/auxiliary tests
- Conclusions
- Progressions
- Discharge Planning



Patient Exits

The reassessment interview – this will establish how the patient feels he/she is responding, identify change in RSSX, identify problem areas and begin the problem-solving process, determine how well he/she is able to apply the TTFB procedures etc.

- **Symptoms** – you need to determine if the location, intensity, frequency and behavior of the symptoms have changed. If so how, if not, why not? Draw the current (today) location of symptoms on the body diagram and compare this to the initial visit.
- **Function** – you need to determine if the patient's ability to tolerate or perform activities, movements, positions has changed. If so how, if not, why not? Compare this to the functional questionnaire ratings.

- **Rating of recovery** – the patient is asked to rate the improvement since the initiation of treatment. Reassure the patient that any answer is acceptable, and that this is simply a method for communication about how he/she feels they are doing in the treatment program.

0 = **no improvement whatsoever (or worse)**
100 = **complete recovery, cured, pain free and function full.**

- **Problem identification** – by the end of the interview you should have isolated the key movements, positions, activities, time periods of the day in which the patient is having difficulty (if any difficulty). You should outline a plan for the patient to fight back against these problems more effectively, and/or you will pursue further testing or training to address these issues directly.

Self-management – assess the patient’s ability to self-manage. You will rate (or ask the patient to rate) the follow through with your instructions. This should include posture (static and dynamic), self-treatment technique and utilization of the TTFB procedures (effective reaction towards effective proaction). We use a 0 – 10 scale with the following anchors: 0 = poor, didn’t follow through with anything. 10 = excellent, perfect follow through.

Self-Efficacy Rating: Poor 0 1 2 3 4 5 6 7 8 9 10 Excellent
--

In general, you need to determine:

- *Cognition* – do they understand what to do and why to do it?
- *Psychomotor* – do they possess the physical skills to carry-out the request?
- *Utilization* – do they know how to apply this knowledge and skill?

TTFB Procedures/Further Testing – at the very least, the patient’s self-treatment procedures (positions, movements) needs to be assessed. However, if the patient is not responding as well as expected, the need to progress or change the treatment strategy should be assessed.

- *Continue treatment plan* – make sure the TTFB procedures are performed correctly and utilized to maximum effectiveness. This reassessment conclusion should mean that the patient is gaining, or has gained, full control over RSSX and they are progressing towards achievement of functional goals with the current strategy. I usually choose this when patient are rating continuous and/or significant improvement (i.e. patient’s rating of recovery) and demonstrate supportive evidence of improvement in RSSx and function. The idea is not to change something that is working, waiting to see if the current strategy is all that is required to solve their problem or until they hit a plateau.
- *Progress/modify the treatment plan* – when the patient is not responding as well as expected, you need to reassess with the intent of finding a way to gain better control over the RSSx and improve function. This can include progressing to the use of manual therapy, various mechanical devices (traction, braces etc.), strategic strength and conditioning, various modalities etc. How you progress or modify the treatment strategy

will depend upon the initial strategy chosen, but the bottom-line is that the plan needs to be adjusted to keep the patient moving towards full recovery or maximum benefit. It is not uncommon to change the treatment strategy during the course of care as you are evaluating the patient's response to treatment (i.e. this is why the outcome data collection distinguishes initial from final treatment strategy). Matter of fact this is expected with the anti-inflammatory strategy, as almost all patients will end up in the posture/ergonomic, reduction or remodeling strategy.

- *Retest to change treatment plan* – if the patient is just not responding well at all (i.e. no improvement or reporting to be worse) this could be due to an incorrect initial conclusion. Wipe the slate clean, and reassess to see if you need to change your conclusions, and to determine how to most appropriately change your treatment plan. Seek help from the referring physician or your colleagues when necessary.
- *Add New Treatment Strategy* – if the current treatment plan has helped, but to a limited degree you may need to change the emphasis of the program. Frequently this occurs when the patient has demonstrated evidence of the ability to improve rapidly, but the control over the RSSx is not complete enough to restore activity tolerance and achieve the functional goals. A common change of treatment strategy would be to initiate a remodeling or stabilization strategy when you are having difficulty achieving the functional goals. However any change is possible depending upon the response of the patient.

Special/other tests – are there specific tests that will provide key information to determine the patient's response to the current treatment plan and/or the need to change (or stop) the intervention strategy.

- *As part of continued treatment plan* – if the patient had neurologic, dural tension or other (special test) finding, you will need to continually reassess these signs to determine if they are static or dynamic.
- *To determine change in treatment plan* – if special test findings are worsening, the program needs to be changed. Possibly (especially if neurologic status is worsening) the patient should be referred back to medical physician.
- *To measure progress or current status* – you may need to perform objective (functional) tests to measure the patient's current functional ability and determine how much (if any) improvement has occurred since the initial visit.

Reassessment conclusions – at the end of each treatment session you should have come to a conclusion about the patient's current response and status, and where you are going from here.

- *Continue same plan unchanged* – the patient is responding appropriately and you should continue with more of the same.
- *Progressions within same treatment plan* – the patient is responding but needs more force in the same direction, or the condition is stable and you need to emphasize reactivation and recovery of activity tolerance.
- *Modify/change treatment plan* – the patient is not responding well enough to continue with the same plan. Identify the change or modification of the current treatment plan.

- *Plan discharge* – the patient has achieved maximal benefit and can progress without further assistance. Make sure you have established and outlined a long-term plan for the patient.
- *Seek consultation* – you suspect more serious pathology, responses are unusual, the patient is not responding, or there is evidence that the condition is worsening.

Clinical Problem-solving – you have to develop the ability to isolate the critical obstacle(s) to recovery, and then find and implement a solution. These skills then need to be transferred to the patient for musculoskeletal self-efficacy.

“ The presence of a problem is the opportunity for a solution! ” *Duffy-Rath*

- *Time* – when (exactly) did the problem develop?
- *Place* – where was the patient when this occurred?
- *Response* – what did the patient do, and when did they do it, in response to the problem?
- *Conclusions* – what are the potential solutions to this obstacle to recovery?

Discharge & Long-term Planning

Planning Discharge and Long-term Management

The Duffy-Rath System© places a great emphasis on patient education, training and self-efficacy. This is intended to reduce the number of visits required and attempts to provide a long-term benefit. Consequently, how you approach discharge planning and long-term instructions is very important.

Identification of maximal benefit – it is easy to determine maximal benefit for a patient who has responded well. It is also easy for a patient that does not respond at all. It is the patient who responds partially that is difficult to recognize maximal benefit from your service. There are several keys to this: 1) Develop some form of objective measurement to demonstrate that the patient’s progress has stalled in spite of all attempts to change/progress treatment. 2) Have confidence that most spine problem do resolve over time, especially with encouragement and a function, activity-oriented long-term plan. 3) Seek a consensus with the patient for their long-term management of the problem.

We recommend that you provide written instructions for the patient to follow at the time of discharge. Provide maximal encouragement, and request that the patient call and report their status/progress on a routine basis. You will be surprised how well many of your patients are doing, especially the ones who really struggled in treatment and were not doing as well as hoped at time of discharge, but with continued exercise have progressed. Follow-up to your discharged patients is an important and educational endeavor.

Training considerations for long-term efficacy – basically, return to a review of the 4 basic principles and the concept of “Tools to Fight Back”. The following will reiterate some of these main themes of the long-term instructions.

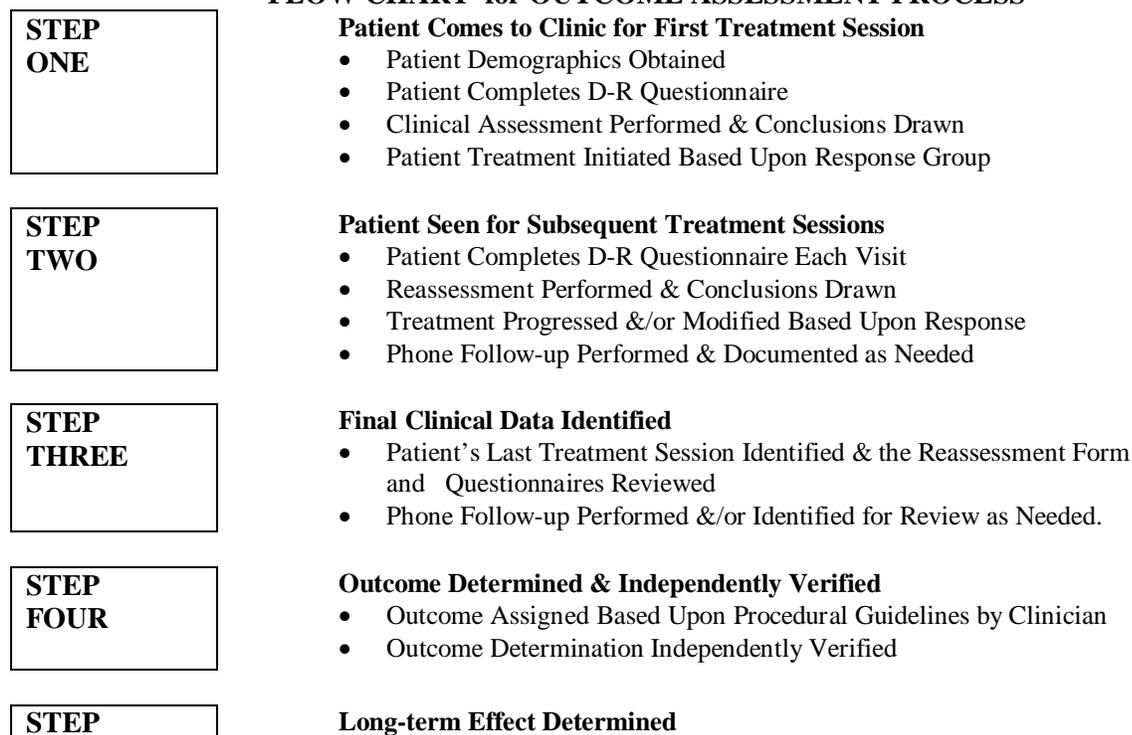
- Review the importance of biomechanical control procedures (posture/ergonomic) as the primary tool to balance the mechanical patterns of stress & strain.
- Review the importance of checking spinal (segmental) motion every day (1 – 2 times) to insure that movement is not lost and as a ‘early detection system’ for a developing problem. Also stress the importance of maintaining extensibility of the external structures for better biomechanical control.
- Review the long-term management of the primary aggravating factors for their individual problem. This usually involves sitting, bending, lifting, sleeping, work and recreational tasks. Reinforce the concept of the ‘opposite movement rule’.
- Review the importance of responding to warning-signs; i.e. listening to their body.
- Review specifically what to do if a recurrent of the Stage II or III disorder occurs.
- Encourage the patient to remain active and continue to build strategic strength and conditioning to ‘toughen tissues’ and build a large margin for safety between physical ability and demand.
- Encourage the patient to call with questions, or to help problem solve if he/she cannot get a recurrent problem back under control quickly.

Outcome Assessment in Clinical Practice (Internal Evidence)

The Duffy-Rath System© is dedicated to ongoing analysis of its interventions and to support good clinical research at all levels of scientific scrutiny. This is the basis for the ‘Internal Evidence’ we discussed in the early part of the workshop.

The following flow-chart will overview the Duffy-Rath Clinical Outcomes process:

FLOW CHART for OUTCOME ASSESSMENT PROCESS



FIVE

- Phone or Office Follow-up Based Upon Procedural Guidelines
- Long-term Outcome Assigned Based Upon Procedural Guidelines

General Outcomes to be Measured (Dependent Variables):

- **Clinical Effectiveness:** Excellent, Good, Fair, Poor, Unknown or Not Applicable clinical result (specified by operative definitions in procedural manual). This should also include assessment of drop-outs from service.
- **Clinical Efficiency:** this will be determined by the number of treatment sessions (visits) and the number of weeks on program.
- **Cost of Service:** initially this will be determined simply by the amount of charges for service and the amount of payment received. Eventually this will include behavioral cost accounting factors to determine the relative worth or value of the time and effort spent in generating the specified amount of income and achieving the eventual clinical outcomes.
- **Follow-up:** this will be determined by phone survey, an office visit or mail survey.
- **Satisfaction:** measurement of the patient's satisfaction with the clinical and office service as determined by the patient satisfaction questionnaires.

Determining the Patient's Outcome

The patient's response to the treatment will be rated according to six categories: 1) excellent, 2) good, 3) fair, 4) poor, 5) unknown, 6) not applicable. These outcomes will be determined by comparing the status of the patient at the initial assessment and treatment visit to the last visit or documented evidence of patient response (this could be a document follow-up phone call etc.). Use the abbreviations below. The following operational definitions must be followed in determining the category of outcome.

E	Excellent – the patient has achieved full control over RSSx, is fully active (i.e. if they were idle, they have returned to work, and function goals have been achieved), rates 90 % recovery or greater, all VAS ratings of pain and disability are less than 2.
G	Good – the patient has achieved full control over RSSx, is fully active (i.e. if they were idle, they have returned to work, but this may be to restricted duty, and function goals have been achieved), rates 70 % recovery or greater, all VAS ratings of pain and disability are less than 5 (unless the response group was non-organic. In this case the VAS ratings had to improve, but do not need to be all less than 5).
F	Fair – there has been measured improvement in some or all of the criteria, but not enough to be placed into the good category.
P	Poor – the patient demonstrated no improvement in any subjective, objective or functional measurements.
U	Unknown – the patient dropped-out so the outcome to treatment is not known, and there is not enough data or enough visits to identify a category. As a general rule, any patient seen for 4 or more visits has to have an outcome.
N	Not Applicable – the intent of physical therapy was not to treat (consultation, structured evaluation like an FSE etc.).

Patient Satisfaction – identify the patient's level of satisfaction with the care they received, as measured by completion of the Duffy-Rath Satisfaction Survey. There are 5 levels of response: 2 positive, 2 negative and 1 neutral. Use the abbreviations listed below. The following operational definitions must be followed in determining the category of outcome.

E	Excellent – all questions are answered with the highest possible rating of satisfaction.
G	Good – all questions answers are answered with a positive response, but not all are the highest possible rating.
F	Fair – there is a mixture of positive and negative responses.
P	Poor – all responses are negative.
U	Unknown – the survey was not completed, or the patient indicates no opinion for the questions.

Verification of Outcome Category – the outcome category must be verified by a non-treating therapist. If they agree to the outcome you have selected, they should just place their initials in the appropriate column. If the outcome is changed, the verifier should indicate this by placing an arrow up (meaning the outcome was improved from your original determination) or an arrow down (meaning the outcome was reduced from your original determination) and then putting their initials in the appropriate column. No arrow up or down, and just the initials indicates that the outcome category was not changed.

References - Introduction

Cote P, Cassidy JD, Carroll L. The Saskatchewan Health and Back Pain Survey: The Prevalence of Neck Pain and Related Disability in Saskatchewan Adults. *Spine*. 23(15):1689-1698, August 1, 1998.

Ferrari R, Russell AS. Epidemiology of whiplash: an international dilemma. *Ann Rheum Dis* 1999;58:1-5.

Hackett GI, Hudson MF, Wylie JB, et al. Evaluation of the efficacy and acceptability to patients of a physiotherapist working in a health centre. *BMJ* 1987;294:24-6.

Kramer J: Intervertebral Disk Diseases. Chicago, 2nd Ed. Thieme Med Pub, New York, 1990.

Kuorinka, I. And Viikari-Juntura, E., 1982, Prevalence of neck and upper limb disorders (NLD) and work load in different occupational groups: problems in classification and diagnosis, *J Hum Ergol*, 11, 65-72.

Kvarnstrom S. Occurrence of musculoskeletal disorders in a manufacturing industry with special attention to occupational shoulder disorders. *Scand J Rehabil Med Suppl* 1983;8:1-114.

Lamberts H, Brouwer H, Groen AJM, et al. The traditional model in practice [Dutch]. *Huisart Wet* 1987;30:105-13.

Linton SJ, Kamwendo K. Risk factors in the psychosocial work environments for neck and shoulder pain in secretaries. *J Occ Med* 31 (7): 609 – 613, 1989.

Mäkelä M, Heliövaara M, Sievers K, et al. Prevalence, determinants, and consequences of chronic neck pain in Finland. *Am J Epidemiol* 1991;134:1356-67.

Mayer TG, Gatchel RJ, Polatin PB, Evans TH. Outcomes comparison of treatment for chronic disabling work-related upper-extremity disorders and spinal disorders. *JOEM* 41 (9): 761-770, 1999.

Nachemson AL, Jonsson E. Neck and Back Pain: The scientific evidence of causes, diagnosis, and treatment. Lippincott Williams & Wilkins, Philadelphia, 2000.

Ohara, H., Itani, T. and Aoyama, H., 1982, Prevalence of occupational cervicobrachial disorder among different occupational groups in Japan, *J Hum Ergol*, 11, 55-63.

Ohlsson, K., Attewell, R. and Skerfving, S., 1989, Self-reported symptoms in the neck and upper limbs of female assembly workers, *Scand J Work Environ Health*, 15, 75-80.

Squires B, Gargan MF, Bannister GC. Soft-tissue injuries of the cervical spine: 15 year follow-up. *J Bone Joint Surg Br* 1996;78:955-7.

Spitzer WO, Skovron ML, Salmi LR, et al. Scientific monograph of the Quebec Task Force on whiplash-associated disorders: redefining "whiplash" and its management. *Spine* 1995;20(suppl 8):1-73.

Waaalen D, White P, Waaalen J. Demographic and clinical characteristics of chiropractic patients: a 5-year study of patients treated at the Canadian Memorial Chiropractic College. *J Can Chiropract Assoc* 1994;38:75-82.

References – Functional Anatomy

Basmajian JV, DeLuca CJ. Muscles Alive: their function revealed by electromyography, 5th Edition. Williams & Wilkins, Baltimore, 1985.

Brieg A Adverse Tension in the Central Nervous System. John Wiley & Sons, New York, 1979.

Butler D, Gifford L (1989) The concept of adverse mechanical tension in the nervous system. Part 1: Testing for 'Dural Tension'. *Physiotherapy* 75:11:622-629

Butler D, Gifford L (1989) The concept of adverse mechanical tension in the nervous system. Part 2: Examination and treatment. *Physiotherapy* 75:11:629- 636

Clarys JP, Barbaix E, Van Rompaey H, Caboor D, Van Roy P. The muscular arch of the axilla revisited: its possible role in the thoracic outlet and shoulder instability syndromes. *Manual Therapy* 1 (3): 133-39, 1996.

Cuetter, A.C. and Bartoszek, D.M., 1989, The thoracic outlet syndrome: controversies, overdiagnosis, overtreatment, and recommendations for management, *Muscle & Nerve*, 12, 410-419.

Cyriax J: Textbook of Orthopaedic Medicine: Volume One. Diagnosis of Soft Tissue Lesions, 8th Edition. London, Bailliere Tindall, 1982.

Elvy RL Treatment of arm pain associated with abnormal brachial plexus tension. *Australian J Physiotherapy* 32: 225-30, 1986.

Eraheim NA, An HS, Rongming X, et. al. The quantitative anatomy of the cervical nerve root groove and the intervertebral foramen. *Spine* 21 (14): 1619-23, 1996.

Harms-Ringdahl K: On Assessment of Shoulder Exercise and Load Elicited Pain the Cervical Spine. *Scand J Reh Med [Suppl 14]:* 1-40, 1986.

Harms – Ringdahl, K. and Ekholm, J. Intensity and character of pain and muscular activity levels elicited by maintained extreme flexion position of the lower-cervical-upper-thoracic spine, *Scand J Rehab Med*, 18, 117-126, 1986.

Harms-Ringdahl K, Schüldt K. Maximum neck extension strength and relative neck muscular load in different cervical spine positions. *Clin Biomech* 1988; 4: 17-24.

Kapandji IA The Physiology of the Joints: Volume 3 The Trunk and The Vertebral Column, 2nd Ed. Churchill Livingstone, Edinburgh, 1974

Kendal FP, McCreary EK, Provance PG. Muscles: Testing and Function, 4th Ed Williams & Wilkins, Baltimore, 1993.

Kopell HP, Thompson WAL. Peripheral Entrapment Neuropathies, 2nd Edition. Robert E Kreiger, Huntington, NY, 1976.

Loeser, JD, Butler, SH, Chapman CR, Turk DC. Bonica's Management of Pain, 3rd Edition. Lippincott Williams and Wilkins, Philadelphia, 2001.

MacConaill MA, Basmajian JV. Muscles and Movements a basis for human kinesiology, 2nd Ed. Robert E. Krieger Publishing, Huntington, New York, 1977.

Ordway NR, Seymour RJ, Donelson RG, et al. Cervical flexion, extension, protrusion and retraction: a radiographic segmental analysis. *Spine*. 240-248, 24 (3), 1999.

Panjabi MM, White, AA. Biomechanics in the musculoskeletal system. New York : Churchill Livingstone, 2001.

Penning, I: Differences in Anatomy, Motion, Development and Aging of the Upper and Lower Cervical Disk Segments' *Clin Biomech* 3(1): 37-47, 1988.

Turk DC, Melzack R: Handbook of Pain Assessment. The Guilford Press, New York, 1992.

Warwick R, Williams PL. Gray's Anatomy: 35th British edition WB Saunders, Philadelphia, 1973.

References – History & Basic Examination

Andersson, G.B.J., Deyo, R.A. (1996). History and physical examination in patients with herniated lumbar discs. *Spine*, 21, 24S, 10S-18S

Biering-Sorensen F: Physical measurements as risk indicators of low-back trouble over a one-year period. *Spine* 9 (2): 106-119, 1984.

Cloward RB: Cervical Discography: A Contribution to the Etiology and Mechanism of Neck, Shoulder and Arm Pain. *Ann Surg* 150(6): 1052-1064, 1959.

Coman W B Dizziness related to ENT conditions. In: Grieve G P (ed) *Modern manual therapy of the vertebral column*. Churchill Livingstone, Edinburgh, pp. 303-314, 1986.

Deyo R: Measuring the Functional Status of Patients with Low Back Pain. *Arch Phy Med Rehab* 69: 1044-1053, 1988.

Dieck GS, Kelsey JL, Goel VK, et al: An Epidemiologic Study of the Relationship Between Postural Asymmetry in the Teen Years and Subsequent Back and Neck Pain. *Spine* 10 (10): 872-877, 1985.

Fairbank JCT, Davies JB, Couper J, et al: The Oswestry Low Back Pain Disability Questionnaire. *Physiotherapy* 66 (8): 271-273, 1980.

Grant R Dizziness testing before cervical manipulation - Can we recognise the patient at risk? In: Dalziel B A, Snowsill J C (eds) *Proceedings, Fifth biennial conference MTAA, Melbourne, Vic, Nov 1987*

Harms – Ringdahl, K. and Ekholm, J., 1986, Intensity and character of pain and muscular activity levels elicited by maintained extreme flexion position of the lower-cervical-upper-thoracic spine, *Scand J Rehab Med*, 18, 117-126.

Jull G, Bogduk N, Marsland A The accuracy of manual diagnosis for cervical zygapophyseal joint pain syndromes. *Med J Aust* 148 (5): 233 –236, 1988.

Lew PC, Lewis J, Story I. Inter-therapist reliability in locating latent myofascial trigger points using palpation. *Manual Therapy* 2 (2): 87-90, 1997.

Main CJ, Wood PLR, Hollis S, Spanswick CC, Waddell G: The distress and risk assessment method: a simple patient classification to identify distress and evaluate the risk of poor outcome. *Spine* 17 (1): 42-52, 1992.

Matheson LN, Mooney V, Grant JE, et al: A test to measure lift capacity of physically impaired adults: Part 1- development and reliability testing. *Spine* 20(19): 2119-2129, 1995.

Matheson LN, Mooney V, Holmes D, et al: A test to measure lift capacity of physically impaired adults: Part 2- reactivity in a patient sample. *Spine* 20(19): 2130-2134, 1995.

Million R, Hall W, Haavik Nilsen K, et al: Assessment of the Progress of the Back-Pain Patient. *Spine* 7 (3): 204-212, 1982.

Nachemson AL, Jonsson E. Neck and Back Pain: The scientific evidence of causes, diagnosis, and treatment. Lippincott Williams & Wilkins, Philadelphia, 2000.

Nelson MA, Allen MB, Clamp SE, et al: Reliability and Reproducibility of Clinical Findings in Low-Back Pain. *Spine* 4 (2): 97-101, 1979.

Rath W. Standardization of terms used in the assessment of pain/symptom responses when mechanical forces are applied to the musculoskeletal system of the human body. *McKenzie Institute Newsletter, US.* 1 (4), 25 – 30, 1993.

Schellhas KP, Latchaw RE, Wendling LR, Gold LH. Vertebrobasilar injuries following cervical manipulation. *JAMA* 244 (13): 1450 – 1453, 1980.

Huckisson EC: Measurement of Pain. *Lancet* 2: 1127-1131, 1974.

Scott J, Huskisson EC: Accuracy of Subjective Measurements Made With and Without Previous Scores: An Important Source of Error in Serial Measurement of Subjective States. *Ann Rheum Dis* 38: 558-559, 1979.

References – Search for TTFB, Conclusions & Treatment Strategies

Cyriax J (1971) Textbook of Orthopaedic Medicine. Volume Two. Treatment by Manipulation Massage and Injection. Eighth Edition. Balliere Tindall, London

Kaltenborn FM The Spine: Basic Evaluation and Mobilization Techniques, 2nd Edition. Olaf Noris Bokhandel, Oslo, 1993.

Maitland GD Vertebral Manipulation, 4th Edition Butterworths, London, 1977.

McKenzie R A (1989) A perspective on manipulative therapy. *Physiotherapy* 75:8:440-444

McKenzie R A (1990) The Cervical and thoracic spine. Mechanical diagnosis and therapy Spinal Publications, Waikanae, New Zealand

Mennell J. Science and art of joint manipulation, Vol. II. London, Churchill, 1952.

Mennell JM. Back pain: diagnosis and treatment using manipulative techniques. Little Brown and Co, Boston, 1960.

Mulligan BR. Manual Therapy: “Nags”, “Snags”, MWMs” etc. 3rd Edition Plane View Services, Wellington, New Zealand, 1999.

Myer J, Prakash M, Froelicher V, et. Al. Exercise capacity and mortality among men referred for exercise testing. *N Engl J Med* 346 (11): 269-74, 2002.

Rath W. Cervical Traction, a Clinical Perspective. *Orthopaedic Review*, Vol 13 (8), 29-48, 1984.

Rath JD, Rath W, Mielcarsky E, Waldman R. Low back pain in pregnancy: helping patients take control. *The Journal of Musculoskeletal Medicine*, April 2000; 223 –232.

Williams, MM, Hawley, JA, McKenzie, RA, Van Wijmen, PM: A Comparison of the Effects of Two Sitting Postures on Back and Referred Pain. *Spine* 16 (10): 1185-91, 1991.

References – Conclusions & Treatment Planning

Bronfort G, Evans R, Nelson B, et. al. A randomized clinical trial of exercise and spinal manipulation for patients with chronic neck pain. *Spine* 26 (7): 788 -99, 2001

Evans R, Bronfort G, Nelson B, Goldsmith CH. Two-year follow-up of a randomized clinical trial of spinal manipulation and two types of exercise for patients with chronic neck pain. *Spine* 27 (21): 2383-89, 2002.

Hurwitz EL, Aker PD, Adams AH, et. al. Manipulation and mobilization of the cervical spine. A systematic review of the literature. *Spine* 21 (15): 1746-59, 1996.

Karjalainen K, Malmivaara A, van Tulder M, et. al. Multidisciplinary biopsychosocial rehabilitation for neck and shoulder pain among working age adults. *Cochrane Database Syst Rev* 2000; (3) CD002194

Kitagawa T, Fujiwara A, Kobayash Naok, et. al. Morphologic Changes in the Cervical Neural Foramen due to Flexion and Extension: In Vivo Imaging Study. *Spine*. 29(24):2821-2825, December 15, 2004.

Lindstrom I, Ohlund C, Eek C, et al. The effects of graded activity on patients with subacute low back pain. A randomized prospective clinical study with an operant-conditioning behavioral approach. *Phy Ther* 72: 39-53, 1992.

Rath W. Guidelines for the classification of mechanical headaches. *McKenzie Institute Newsletter, US*. 2(1): 3 – 4, 1994.

Schofferman J, Anderson D, Hines R, Smith G, Keane G: Childhood psychological trauma and chronic refractory low-back pain. *The Clin J Pain* 9: 260-265, 1993.

Schofferman J, Anderson D, Hines R, Smith G, White A: Childhood psychological trauma correlates with unsuccessful lumbar spine surgery. *Spine* 17 (6S): S138- S144, 1992.

Schonstein E, Kenny DT, Keating J, Koes BW. Work conditioning, work hardening and functional restoration for workers with back and neck pain (cochrane review). *Cochrane Database Syst Rev* 2003; (1) CD001822

General References Cervico-brachial Syndrome

Armstrong TJ, Buckle P, Fine LJ, et al. A conceptual model for work related neck and upper limb musculoskeletal disorders. *Scand J Work Environ health* 19 (2), 73-84, 1993.

Baidya KN, Stevenson MG. Local muscle fatigue in repetitive work. *Ergonomics* 31(2), 227-39, 1988.

Barbis JM, Wallace KA. Therapist's management of brachioplexopathy, In. *Hand Rehabilitation*, Ed Hunter., JB Lippincott, Philadelphia.

Brown C. Compressive, invasive referred pain to the shoulder. *Clin Orth* 173: 55 – 62, 1983.

Burtion K, Polatin P, Gatchel R. Psycho-social factors and the rehabilitation of patients with chronic work-related upper extremity disorders. *J Occup Rehabil* 7: 139 – 153, 1997.

Chatterjee, D.S., 1992, Workplace upper limb disorders: a prospective study with intervention, *Occup Med*, 42(3), 129-136.

- Christensen, H., 1986a, Muscle activity and fatigue in the shoulder muscles during repetitive work: an electromyographic study, *Eur J Appl Physiol*, 54, 596-601.
- Cohen, M.L., Arroyo, J.F., Champion, G.D. and Browne, C.D., 1992, In search of the pathogenesis of refractory cervicobrachial pain syndrome, *Med J Aust*, 156, 432-436.
- Colligan, M.J. and Murphy, L.R., 1979, Mass psychogenic illness in organizations: an overview, *J Occup Psychol*, 52, 77-90.
- Cuettel, A.C. and Bartoszek, D.M., 1989, The thoracic outlet syndrome: controversies, overdiagnosis, overtreatment, and recommendations for management, *Muscle & Nerve*, 12, 410-419.
- Hagberg, M., 1984, Occupational musculoskeletal stress and disorders of the neck and shoulder: a review of possible pathophysiology, *Int Arch Occup Environ Health*, 53(3), 269-278.
- Haldeman S: Presidential Address, NASS: failure of the pathology model to predict back pain. *Spine* 15(7): 718-724, 1990.
- Jonsson, B.G., Persson, J and Kilbom, A., 1988, Disorders of the cervicobrachial region among female workers in the electronics industry: a two-year follow up, *International Journal of Industrial Ergonomics*, 3(1), 1-12.
- Kanwendo, K., Linton, S.J. and Moritz, U., 1991, Neck and shoulder disorders in medical secretaries, *Scand J Rehab Med*, 23, 127-133.
- Karas, S.E., Thoracic outlet syndrome, *Clin Sports Med*, 9, 297-310, 1990.
- Mueller JM, Maluf KS Tissue Adaptation to Physical Stress: a proposed 'physical stress theory' to guide physical therapist practice, education, and research. *Phy Ther* 82 (4): 383 – 403, 2002.
- Nassau DW The effects of prework functional screening on lowering an employer's injury rate, medical costs, and lost work days. *Spine* 24 (3): 269 – 274, 1999.
- Nordin M, Andersson GBJ, Pope MH Musculoskeletal Disorders in the Workplace: Principles and Practice Mosby, St. Louis, 1997.
- Rath W. Cervical Traction, a Clinical Perspective, *Orthopaedic Review*, Vol 13 (8), 29-48, 1984.
- Rath WW, Rath JD. Prevention of Musculoskeletal Injury. In: Rothman J, Levine R (eds). Prevention Practice: strategies for physical therapy and occupational therapy. WB Saunders, Philadelphia: 74-114, 1992.
- Rydevik BL, Brown MD, Lundborg G: Pathoanatomy and pathophysiology of nerve root compression. *Spine* 9 (1): 7-17, 1984.
- Rydevik BL, Myers RR, Powell HC: Pressure increase in the dorsal root ganglion following mechanical compression: closed compartment syndrome in nerve roots. *Spine* 14 (6): 575-577, 1989.
- Rydevik BL, Pedowitz RA, Hargens AR, et al: Effects of acute graded compression on spinal nerve root function and structure. *Spine* 16 (5): 487-493, 1991.
- Sallstrom, J. and Schmidt, H., 1984, Cervicobrachial disorders in certain occupations with special reference to compression in the thoracic outlet, *Am J Ind Med*, 6, 45-52.
- Slamminen, J.J., Pentti, J., Wickstrom, G., 1991, Tenderness and pain in the neck and shoulders in relation to type A behavior, *Scand J Rheumatol*, 20, 344-350.

Schuldt, K., Ekholm, J., Harms-Ringdahl, K., Nemeth, G. and Arborelius, U.P., 1987, Effects of arm support or suspension on neck and shoulder muscle activity during sedentary work, *Scand J Rehab Med*, 19, 77-84.

Takala, E.-P. and Viikari, Juntura, E., 1991, Muscle force, endurance and neck-shoulder symptoms of sedentary workers: and experimental study on bank cashiers with and without symptoms, *International Journal of Industrial Ergonomics*, 7, 123-132.

Tola, S., Riihimaki, H., Videman, T., Biikari-Juntura, E. and Hanninen, K., 1988, Neck and shoulder symptoms among men in machine operating, dynamic physical work and sedentary work, *Scand J Work Environ Health*, 14, 299-305.

Toomingas, A., Hagberg, M., Jorulf, L., Nilsson, T., Burstrom, L. and Kihlberg, S., 1991, Outcome of the abduction external rotation test among manual and office workers, *Am J Ind Med*, 19, 215-227.

Waris, P., 1979, Occupational cervicobrachial syndromes, *Scand J Work Environ Health*, 5(suppl 3), 3-14.

Waris, P., Kuorinka, I. and Kurppa, K., 1979, Epidemiologic screening of occupational neck and upper limb disorders: methods and criteria, *Scand J Work Environ Health*, 5(suppl 3), 25-38.

Webster B, Snook S. The cost of compensable upper extremity cumulative trauma disorders. *J Occup Med* 36: 713-727, 1994.