Whiplash-associated disorders from a physical therapy and health-economic perspective

A study of an active physical therapy involvement and intervention for the treatment of acute whiplash-associated disorders and an analysis of its costs and consequences.

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"To laugh often and much; to win the respect
of intelligent people and the affection of children;
to earn the appreciation of honest critics and endure
the betrayal of false friends; to appreciate beauty,
to find the best in others; to leave the world a little better;
whether by a healthy child, a garden patch or a redeemed
social condition; to know even one life has breathed easier
because you have lived. This is the meaning of success."

Ralph Waldo Emerson

A designer knows that he has achieved perfection,
not when there is nothing left to add,
but when there is nothing left to take away.

Antoine de St-Expurey

Contents

Abstract

WHIPLASH-ASSOCIATED DISORDERS FROM A PHYSICAL THERAPY AND HEALTH-ECONOMIC PERSPECTIVE

A study of an active physical therapy involvement and intervention for the treatment of acute whiplash-associated disorders and an analysis of its costs and consequences.

Whiplash-associated disorders (WAD) resulting from a biomechanical event in motor vehicle collisions is a major cause of suffering and high costs to society. The overall aim of this thesis was to evaluate the clinical and cost-effectiveness of an active physical therapy involvement and intervention in patients exposed to neck trauma in motor vehicle crashes compared to a standard intervention which was common practice in Sweden.

The thesis consists of a review (I) and an intervention study (II-IV). The objective of paper I was to review the literature systematically to analyse the evidence basis of many commonly used treatments for patients suffering from WAD, both in the acute phase and for patients with persistent symptoms. The methodological quality of 26 randomised clinical trials was analyzed. The median quality scores for all three instruments were poor. Based on the degree of evidence and practical considerations, the following treatments can be recommended: Early physical activity in acute WAD, radiofrequency neurotomy, combination of cognitive behavioural therapy with physical therapy interventions, and coordination exercise therapy in long standing WAD. High-quality RCTs are not common in the field of WAD. More research is needed, particularly on the treatment of long standing WAD.

The objective of paper II was to evaluate an active physical therapy involvement and intervention versus a standard intervention and the importance of early versus delayed onset of treatment. Paper III aimed to compare long-term efficacy of active physical therapy involvement and intervention with standard intervention and the effect of early versus delayed initiation of intervention. The aim of paper IV was to compare the costs of an active involvement and intervention versus a standard intervention and to relate them to the clinical benefits in patients exposed to whiplash trauma in automobile crashes to facilitate decision making regarding intervention and resource allocation. The results of the intervention study showed that the active involvement and intervention was significantly superior in reducing pain intensity and reducing sick leave.

Costs were significantly lower after 6 and 36 months with an active involvement and intervention as compared to the standard intervention.

In conclusion, active involvement and intervention is a cost-saving alternative compared to a standard intervention in patients exposed to whiplash trauma, when costs related to physical therapy treatment and productivity were considered.

It should thus be considered in the choice of treatment of these patients.

List of publications

This thesis is based on the following publications:

I. **Seferiadis A,** Rosenfeld M. and Gunnarsson R. (2004)
A review of treatment interventions in whiplash-associated disorders.
Eur Spine J.

II. **Rosenfeld M,** Gunnarsson R. and Borenstein P. (2000)
Early intervention in whiplash-associated disorders: a comparison of two treatment protocols. Spine 25, 1782-1787.

III. **Rosenfeld M,** Seferiadis A., Carlsson J. and Gunnarsson R. (2003)
Active intervention in patients with whiplash-associated disorders improves long-term prognosis: a randomized controlled clinical trial.
Spine 28, 2491-2498.

IV. **Rosenfeld M,** Seferiadis A. and Gunnarsson R. (2006) *Active Involvement and Intervention in Patients Exposed to Whiplash Trauma in Automobile Crashes Reduces Costs: A randomised, controlled clinical trial and health economic evaluation*. Spine Journal In press.

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Abbreviations and definitions

AII	Active Involvement and Intervention
SI	Standard Intervention
CROM	Cervical Range of Motion
MVC	Motor Vehicle Crash
WAD	Whiplash–Associated Disorders
QTF	Québec Task Force
CPM	Continuous Passive Movement
PT	Physical Therapy
CTR	Cervico-Thoracic Ratio
NIC	Neck Injury Criterion
MDT	Mechanical Diagnosis and Therapy
RCT	Randomized Controlled Trial
CCT	Controlled Clinical Trial

Active physical therapy Therapeutic patient movement

Involvement Getting involved with the patient but not necessarily intervening initially. Can include reassurance, promoting maintenance of regular activities, assessing risk etc.

Centralization Occurs in response to therapeutic loading strategies, pain is progressively abolished in a distal-to-proximal direction with each progressive abolition being retained over time until all symptoms are abolished. If back pain only is present, this moves from a widespread to a more central location and then is abolished.

McKenzie method The McKenzie system of Mechanical Diagnosis and Therapy, classifies musculoskeletal disorders on the basis of the mechanical (such as range of motion) and symptomatic responses (such as pain) to repeated movements, positions and activities derived from the history and assessment. Treatment is predicated on the result of the analysis of these symptomatic responses. Treatment emphasis is on home exercises.

Introduction

Why whiplash?

As a physical therapist in the Swedish primary care system, I regularly met patients suffering from whiplash-associated disorders (WAD). Treatment results varied, and after consulting both colleagues and the literature, soon discovered a lack of consensus concerning several aspects of this disorder. While attending a course on Mechanical Diagnosis and Therapy, Part B, The Thoracic and Cervical Spine, by the McKenzie Institute International, the lecturer, Mark Laslett, presented a treatment protocol for patients with WAD. His claim that patients treated according to this protocol did not develop long-standing symptoms seemed somewhat bold and challenging. Shortly after completing the course in September, 1993, the thought of testing the protocol arose. The results are presented in this thesis.

Perspective of this thesis

The subject of this thesis is WAD from a physical therapy (PT) perspective. To paraphrase the modern Swedish definition of physical therapy adapted by the Scientific Committee and the Board of the Swedish Association of Registered Physical therapists in 1997 [1], the theoretical basis of PT consists of movement science, comprising biomechanical, physiological and psychological factors and perspectives of movement and the specific dysfunctions of movement caused by disease or injury.

The perspective for this thesis in the treatment of patients with WAD was based primarily on the theoretical background and practice of PT while the health economic perspective of the studied treatments deals with cost-effectiveness as defined by Drummond [2]. The unique perspective of PT in the treatment of patients with WAD focuses on movement, whereby encouraging and enabling movement promotes healing and restoration of function.

Whiplash injury

There is a Swedish expression, "kärt barn har många namn" or "a beloved child has many names". Though whiplash injury can hardly be called "a beloved child", it too, has many names. Furthermore, it is a costly injury, causing considerable pain and suffering [3], and has increased in the last decades [4-6]. The many names reflect the controversy surrounding this condition and create difficulties, among other things, in cost-of-illness and diagnostic studies. Regional, national and international comparisons are problematic because of different sources of data, non-standardized diagnostic criteria and terminology. The bony, soft tissue and diverse injuries resulting from brutal, relative intervertebral acceleration and extensive energy transfer spread to structures throughout the body, chiefly in automobile crashes, have been called;

C-spine sprain, C-spine strain, acceleration/deceleration injury, acceleration-deceleration injury, cervical myofascial pain, cervical soft tissue pain syndrome, cervical sprain, cervicobrachial strain, long standing cervical sprain, long standing cervical strain, long standing neck sprain, long standing neck strain, extension-flexion injury, extension/flexion injury, flexion/-extension injury, flexion/extension injury, hyperflexion-hyperextension injury, hyperflexion/hyperextension injury, neck/shoulder girdle soft tissue injury, neck sprain, neck strain, regional soft tissue pain syndrome, whiplash-associated disorders (WAD), whiplash and related disorders, whiplash syndrome and perhaps earliest, "railway spine"(listed as synonyms and related key words in "Cervical Sprain and Strain" at eMedicine.com).

The term railway spine referred to similar symptoms due to minor railway crashes. The diagnosis "railway spine" was a predominantly 19th century British phenomenon. The diagnosis was controversial. Train accidents gave rise to litigation in compensation cases in which posttraumatic symptoms with no apparent lesions were related to spinal damage. Medical opinion differed about the physical or psychic nature of the symptoms. The diagnosis was strongly associated with fraudulent claims for compensation and became obsolete after 1900, when the symptoms were generally diagnosed as a functional neurosis. The railway spine controversy was, thus, a precursor of the modern discussion concerning the validation of posttraumatic symptoms [7]. The term "Whiplash" was first used in a published report in 1945 by Davis [8]. The extensive nomenclature partly reflects the uncertainty of the injury mechanism.

Definitions

Besides being the title of Metallica's first single ever released in North America*, "Whiplash" is also a disorder defined by States [9] as “a collection of symptoms following injury to the neck, usually hyperextension-flexion, often the result of a car accident”. This definition and other similar ones can be misleading whereby it appears limited to cervical spine dysfunction and could be interpreted as excluding other sequelae such as neuropsychic, postural, ocular, cochleovestibular or sensorial involvement, described by Lucas as the ascending cervical syndrome [10].
In “The Scientific monograph of the Quebec Task Force (QTF) on Whiplash-Associated Disorders: redefining "whiplash" and its management” [3] whiplash was redefined as “an acceleration-deceleration mechanism of energy transfer to the neck which may result from rear-end or side impact, predominantly in motor vehicle collisions, but also from diving accidents, and from other mishaps. The energy transfer may result in bony or soft tissue injuries (whiplash injury), which in turn may lead to a wide variety of clinical manifestations (whiplash-associated disorders - WAD)”. This thesis is based on the latter widely accepted definition.

**The usage of the word whiplash has apparently become integrated in the language and is associated with a violent movement of the head, something Metallica´s fans seem to do in rhythm to the music.*

Classification

The classification of whiplash injuries according to the QTF was made in 1995 to facilitate the evaluation of research and to provide useful guidelines for making management decisions. It classified patients according to the type and severity of signs and symptoms observed shortly after the injury according to the following:

0	=	*no neck pain complaints, no physical signs*
I	=	*neck pain complaints, only stiffness or tenderness, no other physical signs*
II	=	*neck complaints and musculoskeletal signs (decreased range of motion and point tenderness)*
III	=	*neck complaints and neurological signs (weakness, sensory and reflex changes)*
IV	=	*neck complaints with fracture and/or dislocation.*

Kivioja et al [11] suggested that the application of the QTF classification was of limited prognostic value. Hartling, on the other hand [12], concluded that it was capable of predicting long-standing WAD. Sterling [13] described the WAD level II as too broad while not taking into account measurable motor, sensory and psychological disturbances. Several studies, according to Sterling [14], showed an enormous variation in symptoms and prognosis in these WAD II patients, thus uncovering an urgent need for reclassification of these patients.

The Swedish Society of Medicine and the Whiplash Commission task force [17], however, considered Sterling's reclassification as too extensive to be useful other than in research, while its prognostic value has not been tested. Their recommendation was to use specific diagnoses rather than classifications to avoid misunderstanding and excessive interpretations.

Incidence and prevalence

WAD occurs commonly after road traffic accidents. The Abbreviated Injury Scale (AIS) [15] is an anatomical scoring system first introduced in 1969 and has been considered a reasonably accurate way of ranking the severity of injury. Injuries are ranked on a scale from 1 to 6 from "minor" (AIS 1) to "virtually unsurvivable injury" (AIS 6).

The AIS 1 neck injuries included in WAD have become the most common traffic injury in Sweden [16]. Swedish data indicate an increase in the number of whiplash injuries from motor vehicle crashes (MVC) during the last decade. According to a recent report [17], more than 30,000 people report neck problems to Swedish insurance companies and according to the Swedish Road Traffic Injuries Commission statistics, approximately 1500 sustain significant impairment. The Swedish Social Insurance Agency statistics show at least 500 per year completely incapable of work as a result of WAD.

The numbers vary, but there appears to be an annual incidence of acute whiplash trauma of 1-4.2 per 1,000 inhabitants and 3.2 per 1,000 for WAD grades 1-3 [18, 19]. A review in the American Journal of medicine [20] reported an incidence of 4 per 1000 inhabitants.

Symptoms of WAD

Dominating symptoms of acute WAD are neck pain, headache and neck stiffness with or without restricted cervical range of motion (CROM) but may also include subjective upper limb weakness, paraesthesia, imbalance and dizziness, impaired vision, sleep disturbances and impaired cognitive functions. Neck pain is usually associated with neck stiffness or restricted movement [21]. Neck pain may also radiate to the head, scapula, shoulder or arm. Headache is the second most common symptom, often sub-occipital or occipital, radiating anteriorly into the temporal or orbital regions [22]. Psychiatric symptoms and disorders are frequent after road accident injury [23].

Pain

The International Association for the Study of Pain defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage". Pain is common after whiplash trauma. In a study by Pearce, all 80 patients reported neck pain while 60% reported short-lived headache (3 weeks) while Gennis reported that 62% had neck pain at more than 6 weeks post trauma [24]. A Swedish study showed that 80% of patients had neck pain and 43% suffered constant pain [25].

Irritation of the brachial plexus

Changes in nerve tension and neural mechanosensitivity may contribute to symptoms of pain and paraesthesia in WAD. Disturbed neurodynamics or altered nerve sliding is apparently a factor in WAD [26]. Nerve irritation is, among other things, caused by stretching of the brachial plexus [27]. Irritation has been noted in patients with WAD and could be a cause of neck and arm pain [14, 28-30].

Restricted cervical range of motion

Neck mobility is reduced in patients with WAD in the acute phase of WAD [31] and long standing phase [25, 32-34]. However both Kasch and Drottning concluded that reduced CROM was not as common in late WAD [31, 35]. In the studies by Dall´Alba et al, Antonaci et al and Prushansky et al, CROM could discriminate between asymptomatic persons and those with persistent WAD [36-38].

Initial, restricted CROM has also been shown to be an important risk factor [39-41]. Normal CROM is important for the return to previous activity levels [42] and should be targeted in treatment of patients with subclinical neck pain [43]. Improving cervical and thoracic range of motion appears to be related to disability scores in patients with WAD [44]. CROM is also important for performing functional tasks of activity [45] although the relationships among cervical spinal pain, impairment, and disability are inexact [46]. In a study by Olson et al, decreased neck rotation, and retraction, were associated with higher disability [47].

Coordination disturbances

Oculomotor problems were seen in a study by Hildingsson et al [48] where the authors suspected possible brain stem damage as the cause. Evidence of altered coordination between the deep and superficial neck muscles, greater neck muscle fatigue under sustained low loads, and deficits in kinaesthetic sense have been identified in symptomatic individuals [49]. Another aspect of disturbed coordination in WAD has been seen in disturbed jaw function with smaller ranges of motion, and changed coordination between mandibular and head-neck movements [50].

Minor traumatic brain injury (MTBI)

MTBI occurs in motor vehicle crashes, resulting in cerebral personality disorders, persistent altered consciousness, post-traumatic stress, psychodynamic reactions to impairment, and complex reactions expressing neurological, somatic, and psychological dysfunctions [51]. Since many of these disorders are observed in WAD, perhaps MTBI is an explanation for these [52].

Headache

MTBI may be a factor behind the very common symptom of headache [53] although some authors look to the upper cervical spine as a source of headache [54, 55]. Drottning considered that cervicogenic headache (CGH) seemed to be present after whiplash injury [56]. CGH is diagnosed from three features: (1) unilateral headache triggered by head/neck movements or posture; (2) unilateral headache triggered by pressure on the neck; (3) unilateral headache spreading to the neck and the homolateral shoulder/arm [57].The exact pathophysiology of headache after trauma is, however, still unknown in many cases [58] but occipital neuralgia, migraine and tension type headache in addition to the above have appeared in the literature [41, 59-61].

Injury Mechanism

Better understanding of the injury mechanism in patients with WAD should improve injury prevention, diagnosis and treatment. Based upon a theory of hyper-extension as the injury mechanism in whiplash [62], the head-restraint was designed to prevent neck injuries in rear-end collisions by blocking hyper-extension of the neck. It decreased injuries, but did not eliminate them. Nygren et al [63] found only a 20% decrease in neck injuries after the introduction of the head-restraint suggesting that the hyper-extension injury mechanism model needed re-examining.

The hyper-extension hypothesis of injury mechanism was not supported by the studies of Panjabi which found a distinct bi-phasic kinematical response of the cervical spine to whiplash trauma. In the first phase, the spine formed an S-shaped curve with flexion at the upper levels and hyper-extension at the lower levels. In the second phase, all levels of the cervical spine were extended, and the head reached its maximum extension. They concluded that the lower cervical spine is injured in hyperextension when the spine forms an S-shaped curve. Further, this occurs in the first whiplash phase before the neck is fully extended. At higher trauma accelerations, they concluded that there was a tendency for the injuries to occur at the upper levels of the cervical spine [64]. These results have led to better injury prevention through improved seat design and have helped clinicians to better understand WAD.

In animal experimental studies, Svensson et al observed changes in the inner volume of the cervical spinal canal during rapid neck extension-flexion motion, causing transient pressure changes in the central nervous system as a result of hydro-dynamic effects. Due to flow resistance and the acceleration effect on fluid mass, they hypothesized that the pressure gradients could generate injurious stresses and strains to exposed tissues, particularly in the intervertebral foramina. They hypothesized further that subsequent mechanical loading of the nerve roots caused observed cell membrane dysfunction in the nerve cell bodies of the cervical spinal ganglia and could possibly explain some of the symptoms associated with soft-tissue neck injuries in car accidents [65].

Rotated head position at the time of the crash has been named as a risk factor for poor prognosis [66]. Considering the prevalence of positive brachial plexus provocation tests in WAD [28-30] one can speculate that perhaps the pretensioning position of the turning the head with hands on the steering wheel might be a mechanism of injury to the brachial plexus.

Pathoanatomy

The neck comprises intricate structures meeting many complex demands. The neural and vascular structures, soft tissues, bones and joints of the neck work interdependently to support the head while linking it to the body. The vertebral column simultaneously provides rigidity and plasticity. The neural and vascular pathways must remain intact and uncompromised while retaining mobility to accommodate the extreme flexibility of the neck. There is also a particular complexity of the upper cervical spine with many intricate connections to the sympathetic nervous system and cranial nerves. This flexibility and complexity is designed to perform within physiological limits and makes the neck vulnerable to injury when these limits are exceeded. The forces to the neck and head in an MVC cannot be considered to lie within these limits [67-69], although there has been much controversy concerning injury thresholds. Severy et al pointed out in 1955 that long-lasting symptoms as a result of minor soft tissue injuries of the neck were characteristic not of the forces on the neck in an accident but of the nature of the neck [70].

The joint capsules, ligaments, tendons and skeletal muscles protect the structures of the neck by absorbing energy in trauma and it is in these structures that injuries can be expected. The neck injuries seen after road traffic accidents are often described as sub failure, mechanical injuries such as sprains or strains. These are complete or partial tears of ligaments, muscles or tendons from over-extension of a joint or twisting or pulling of muscles or tendons. Several studies of the cervical spine after fatal road traffic injuries using optimal autopsy techniques have revealed many lesions that can also be suspected in survivors of road traffic traumas even if extrapolation of findings may not be justified. One of the earliest of these studies was by Jonsson et al [71]. 22 cervical spines from traffic accident victims with fatal craniocerebral injuries were examined. 245 bone and discoligamentous lesions were seen using cryosectioning whereby all injuries were recorded at submillimeter intervals on high resolution film. Multiple-level soft-tissue injuries were common and practically all the injuries were radiologically undetected despite fine-focus specimen radiograms taken in special views and evaluated by an expert orthopaedic radiologist.

Schonstrom et al found extracapsular bruising around the second spinal nerve and its dorsal root ganglion, posterior to the joint, fractures of the articular surfaces of the lateral masses of C1, posterior, extraarticular haematomas, abnormal discoloration of the posterior synovial folds and anterior capsular rupture [72]. Additionally, Taylor and Twomey found injuries to the cartilage plates of the intervertebral discs, hemarthrosis of the zygoapophysial joints, traumatic disc ruptures with herniation, anular bruising and zygoapophysial cartilage fracture [73]. Taylor et al found multiple lesions to the facet joints and the intervertebral discs while no similar lesions were found in a nontraumatized control group [74].

These injuries to the stabilizing structures of the spine elegantly described by Panjabi [75, 76] may lead to dysfunction and instability and compensation mechanisms such as the recruitment of other uninjured structures. Briefly, he describes three subsystems which must be intact to maintain spinal stability:

1. *A passive subsystem consisting of the vertebrae, discs and ligaments.*

2. *An active subsystem of muscles and tendons which can apply stabilising forces to the spinal column.*

3. *The neural subsystem constantly supplying the active subsystem with feedback to provide necessary stability.*

Pathological instability, however, as stated below, is rare in acute WAD, therefore it may be more appropriate to speak of disturbances in segmental mobility as described by Norlander detectable using the Cervico-Thoracic Ratio (CTR) [77]. CTR is a clinical method for measuring segmental mobility between C7 and T5, to evaluate the influence of segmental mobility in neck-shoulder pain and different subjectively experienced symptoms. Norlander suggested that deviation from synchronous distribution of mobility between motion segments C7-T1 and T1-T2 might be a factor stimulating joint mechano-receptors. Variations in segmental mobility significantly correlated to variation in hand weakness, headache, mental stress, dizziness and pain in the heart region [78]. Interestingly, unpublished data showed that it was 3 times more usual for patients with WAD to have disturbed segmental mobility according to CTR compared with non-whiplash patients with neck-shoulder pain (personal communication with Staffan Norlander). A review from 2004 concluded that mobilization and/or manipulation when used with exercise are beneficial for persistent mechanical neck disorders which included patients with WAD I-III [79]. These mechanical neck disorders include the disturbed segmental mobility described by Norlander.

Pathophysiology

The results of one study showed that there exist reflex connections between receptors in cervical facet joints and fusimotoneurones of dorsal neck muscles in the cat, and this might be of importance in the pathophysiology behind WAD. Thus, potential damage to the facet joints may not only be a source of pain [80], but also of disturbed muscle tonus which in turn may cause disturbances in proprioception [81]. Furthermore, trauma causing injury to other receptor bearing structures such as ligaments, joints and muscles will impair proprioceptive information [82]. Increasing muscular co-activation [83] and non-optimal postures may be a consequence of reduced accuracy of proprioceptive information. Gimse et al concluded that dizziness in WAD was caused by abnormal proprioception from the neck [84].

According to Curatolo et al there is consistent evidence for hypersensitivity of the central nervous system to sensory stimulation in long standing pain after whiplash injury. Tissue damage, detected or not by the available diagnostic methods, according to Curatolo, is probably the main determinant of central hypersensitivity [85]. Part of the explanation of long standing pain can thus be explained by central or spinal hyperstensitivity [86-89] although it has also been seen in the acute stage [14].

Injury thresholds

To develop a standard for safety research in the area of neck injury prevention in rear-end collisions, a neck injury criterion (NIC) was proposed by Bostrom et al. in 1996 [65, 90]. This criterion uses differential horizontal acceleration between the head and the T1 vertebra to assess the neck injury risk. The theory behind the Neck Injury Criterion indicates that the neck injury occurs early on in a rear-end collision. The NIC has even proven to be applicable in real-life crashes: the higher the NIC, the greater the risk for injury. This has had consequences for the prevention of WAD in car seat design [91, 92].

Several studies point out that a discussion of minimum injury thresholds is irrelevant and that similar forces affect people differently. Some will be injured and some will not. Some will develop symptoms and some will not. The conclusion is to examine crash data but most important is to evaluate each patient individually [93, 94]

Prognosis after whiplash trauma

Healing of damaged structures

According to Buckwalter and Grodzinsky, mechanical loading is imperative for the healing process [95]. Thus, physical activity which entails loading of injured musculoskeletal tissue appears to be vital in the treatment of musculoskeletal injuries. A study of healing anatomical soft-tissue after controlled muscle strain in animal models showed at 24 hours, fiber necrosis and infiltration of inflammatory cells, edema, and hemorrhage. At 48 hours there was complete fiber breakdown and intense inflammatory cell proliferation. At 7 days inflammation was reduced and collagen fibrosis more advanced. The scar tissue was inelastic but function had returned to normal after 7 days [96].

The type I soft tissue sprain occurs without alteration of structural integrity with little or only minor initial pain or swelling and healing is within 3 weeks. Type II implies a moderate stretch with some partial tearing and immediate pain onset. Complete tissue healing is expected within 6 weeks. Recovery of type III sprains are usually excellent by about 3 to 6 months, but may not be complete in all cases. Injuries to the discs heal slowly or not at all [73]. Healing of nerves is slow and unpredictable [3].

Recovery of function

The prognosis for WAD is usually described as good with only a small percentage with delayed recovery. The figures, however, vary considerably, depending on the study. Studies have shown that cervical spine injuries in motor vehicle crashes result in long-standing symptoms [97-99]. Squires et al found 70% reporting symptoms attributable to the original crash at 15 years [100] and Bunketorp et al reported 55% with persistent neck pain in a group of 121 patients with neck complaints following an MVC, 17 years after the MVC. In a control group where 34% had been exposed to an MVC, 270 (29%) reported neck pain. There was a significant difference between the exposed group and the control group regarding the occurrence of neck pain [101]. In a study of 586 patients diagnosed with whiplash injury, 7% did not return to work [102]. In a Swedish study, during a period of 2.5 years, 40% (103/255) of those injured had been on sick leave totaling 12,500 days, concluding that this type of injury accounts for a high proportion of disability pension cases [103].

Risk factors predicting prognosis

The prognostic value of symptoms and factors for predicting outcome after whiplash trauma has been investigated in several studies;

- *Several reviews and studies indicate strong evidence for high initial pain intensity being an adverse prognostic factor and an important predictor for delayed functional recovery for patients with WAD [40, 104-106].*

- *There is conflicting evidence for sociodemographic factors whereby some reviews say that increased age and female gender are risk factors [105, 107, 108] while others say they are not [104].This discrepancy is most likely due to differing filtering standards of quality.*

- *LeClerc et al [108] found psychological stress and psychosomatic problems to be a negative predictor for neck pain in general.*
  Some recent studies have found that coping strategies and self-efficacy may be important indicators of outcome [109, 110].

- *Crash-related factors may also be important [105, 111] although the degree of vehicle damage does not seem to be a factor [112].*
  Prognostic factors associated with other pain conditions possibly relevant in WAD;

- *Factors influencing the prognosis of other pain conditions, such as back pain are patient beliefs of a serious disease, negative expectations (condition will worsen) fear-avoidance behaviour, cognition errors, catastrophizing, maladaptive coping strategies, depression and anxiety [113].*

- *Job dissatisfaction also plays a role in the development of disabilities, and the work place, particularly employers inaction or lack of assistance, seems to be decisive in return to work after illness or injury [114].*

Treatment of acute whiplash injury

Treatment for WAD has included both invasive [115, 116] and noninvasive interventions, but most studies of treatment of the initial phase of WAD utilize noninvasive physical therapy (PT). The PT studies claimed with varying degrees of evidence that early physical activity reduces pain, increases cervical range of motion and reduces sick leave in patients with acute WAD [24, 117-121]. In 1994 when the studies in this thesis were planned, little knowledge existed of PT intervention in WAD. Theoretically, but at the time unproven, were the possible treatment options based on continuous passive movement (CPM) [122] and McKenzie method of mechanical diagnosis and therapy [123].Neither cervical traction nor collars appear to have any benefit in WAD [126, 127]. There is little evidence in the literature for most of the physical modalities (heat, massage, ultra-sound etc.) used for pain relief in physical therapy, but they appear to have high patient satisfaction. If these modalities are applied, it is important that patients are informed of the important role of movement and activity in healing of injured soft tissue and recovery of function. It must also be remembered that the absence of evidence is not the evidence of absence. Treatment should be based on scientific evidence and extensive clinical skills and experience when studies are lacking.

Continuous passive movement (CPM)

Salter´s studies of articular cartilage healing and regeneration and CPM implied that CPM stimulates pluripotential mesenchymal cells to differentiate into articular cartilage and thus accelerates the healing of articular tissues [128]. Thus, CPM and its effect on joint healing was the motivation for introducing the rotational exercises of the active intervention in the intervention study presented in this thesis.

The McKenzie system

The McKenzie system of Mechanical Diagnosis and Therapy, classifies musculo-skeletal disorders on the basis of the mechanical (such as range of motion) and symptomatic responses (such as pain) to repeated movements, positions and activities derived from the history and assessment [123]. Treatment is predicated on the result of the analysis of these symptomatic responses. Treatment emphasis is on home exercises. According to the McKenzie Institute International, "unique to the McKenzie Method® is a well-defined algorithm that leads to the simple classification of musculoskeletal disorders. The McKenzie classification of spinal pain provides reproducible means of separating patients with apparently similar presentations into definable sub-groups (syndromes) to determine appropriate treatment. McKenzie has named these three mechanical syndromes: Posture, Dysfunction and Derangement.

- *Posture syndrome: End-range stress of normal structures.*
- *Dysfunction syndrome: End-range stress of shortened structures (scarring, fibrosis, nerve root adherence).*
- *Derangement syndrome: Anatomical disruption or displacement within the motion segment.*

All three mechanical syndromes – postural, dysfunction, and derangement – occur in the cervical as well as thoracic and lumbar regions of the spine.

Each distinct syndrome is addressed according to its unique nature with mechanical procedures utilizing movement and positions. The Derangement syndrome where the phenomenon of "centralization" [129] occurs is most common". The details of the Mckenzie methods used are presented in the methods section.

Aims

General aims

The lack of consensus concerning physical therapy (PT) and the paucity of randomized, controlled trials of PT was the chief motivation for this thesis.
The aim of this thesis was to evaluate an active PT involvement and intervention for patients at risk for whiplash injury after an MVC from a clinical and health economic perspective.

Specific aims

The specific aims of this thesis were:

- *in study I, review the literature systematically using three instruments to perform a qualitative analysis of the evidence basis of many commonly used treatment options for patients suffering from acute and long standing WAD.*

- *in study II, to compare the efficacy of an active involvement and intervention, with that of a standard treatment protocol for acute whiplash injuries and to investigate the importance of early versus delayed initiation of treatment.*

- *in study III, to evaluate the long-term efficacy of active involvement and intervention compared with standard intervention for patients with WAD and to investigate the importance of early versus delayed initiation of intervention.*

- *in study IV, to compare the costs of an active involvement and intervention versus a standard intervention and to relate the costs to the clinical benefits in patients exposed to whiplash trauma in automobile crashes.*

Methods

Review (I)

Selection of studies

The selection aimed at retrieving all randomized controlled trials (RCT) presenting an intervention aimed to improve the outcomes following WAD. The Medline database was searched from 1962 through May 2003. The WebSPIRS 5.02 program was used to search the databases CINAHL (1960 to 2003), Embase (1976 to 2003) and Psych-info (1960 to 2003). The search was conducted on the MESH term "whiplash" and the word "whiplash" in the abstract or title of the study. Titles and abstracts of identified published articles were reviewed by one of the authors (AS). All intervention studies dealing with acute or long standing WAD were retrieved. The reference lists of relevant RCTs and controlled clinical trials (CCT) were checked to identify additional published research not found in the computerized bibliographic databases. Saturation was tested by checking reference lists of relevant studies. When no further studies were found that were not found in the database search, saturation was considered complete.

Scoring methods

All RCTs found were evaluated using the three most widely accepted criteria lists;

1. Instrument to Measure the Likelihood of Bias in pain research reports (IMLB) by Jadad et al. [130].

2. The Delphi List (DL) by Verhagen et al. [131].

3. The criteria list for methodological quality assessment also known as Maastricht-Amsterdam List (MAL) by the back review group of the Cochrane Collaboration.

The methodological quality of the studies was independently assessed by two reviewers (AS and MR). All studies received a score for each of the criteria lists IMLB, DL, and MAL. In case of any disagreement between the two reviewers a consensus method was used. If disagreement persisted, a third reviewer (RG) would make the final decision. A pilot assessment of one RCT (not included in the study) was conducted to familiarize the reviewers with the quality assessment lists. Prior to scoring, the reviewers discussed the available guidelines to ensure a common interpretation of the lists. After the individual assessment, the reviewers then agreed on a final score for each article.

The IMLB consists of three items directly related to the reduction of bias, treatment allocation, follow-up/withdrawals, and blinding. The items were presented as questions to elicit yes or no answers. One point was awarded for each affirmative answer. Additionally, one point was added or deducted if the methods used were appropriate or not. This gives a numerical sum score of 0–5.

The DL consists of nine items concerning study population, treatment allocation, outcome measures, blinding, and analysis. All items have yes/no/don't know options. If bias was unlikely, the item was rated with one point. If information was unavailable or insufficient or if bias was likely, the item was rated with zero points for an overall numerical sum score of 0–9.

The MAL consists of 19 items related to population, treatment allocation, study design, intervention, outcome measures, follow up/withdrawals, blinding, cointerventions, side-effects, compliance, and analysis. It includes items similar to the IMLB and DL and unique items. The response options are similar to DL, and the overall numerical score is 0–19.

Best-evidence synthesis

A qualitative analysis ("best-evidence synthesis") was conducted using a rating system utilized by the Cochrane Collaboration Back Group [52]. It consists of the following degrees of evidence:

1. *Strong evidence: generally consistent findings in multiple high quality RCTs.*

2. *Moderate evidence: generally consistent findings in multiple low quality RCTs and/or one high quality RCT.*

3a. *Limited evidence: only one low quality RCT.*
3b. *Conflicting evidence: inconsistent findings in multiple RCTs.*

4. *No evidence: no RCTs and no double-blind trials.*

A study was arbitrarily judged to be of high quality if the sum score in all three scales (IMLB, DL, and MAL) was at least 50% of the total score.

Statistics

The different scores of the criteria lists are presented Table 3 of the review (I). Kappa was calculated to estimate interobserver reliability of quality assessment.

Intervention studies (II-IV)

Patients were randomized to an intervention using frequent active cervical rotation complemented by assessment and treatment according to McKenzie’s principles or to a standard intervention of initial rest, recommended soft collar, and gradual self-mobilization. To test the time factor, interventions were either made within 96 hours or delayed 14 days from collision. The effects of the two interventions and the time factor on pain intensity, CROM, costs and sick leave were analyzed at 6 months and 3 years. Cervical range of motion at 3 years was also compared with that in matched, unexposed individuals.

Ethical aspects

The study was approved by the Regional Ethical Review Board, at Göteborg University.

Setting

The study was carried out at a primary care unit in Sandared, located in the southern half of Elfsborg County in the southwestern part of Sweden, a mixture of urban, village, and rural populations.

Study design

Prospective randomized trial in 97 patients exposed to acceleration/deceleration forces in motor vehicle collisions.

Selection of patients

Physicians in 29 primary care units, three emergency wards and several private clinics selected patients consecutively during March 1995 to March 1996. Criteria for inclusion were exposure to whiplash trauma caused by rapid movements of the head resulting from acceleration forces in any vector produced in a motor vehicle collision. Cervical spine radiography was performed on all patients. Patients with neurological deficits (WAD III), cervical fractures or dislocations (WAD IV), head injury, previously known symptomatic long standing neck problems, alcohol abuse, dementia, serious mental diseases, or diseases that could be expected to lead to death before the study's completion were not included. Patients that could be randomized within 96 hours after collision were referred to the study.

Randomization

This was a non-matched, randomized study using a two factor design.
The purpose of the design was twofold:

- *To randomly allocate patients to four groups.*
- *To create as equally-sized groups as possible.*

A block randomization known as complete randomization was used. It is similar to a block randomization usually utilized in a matched study, although this study was not matched. The procedure was as follows:

1) Denote the four groups: A, B, C and D.

2) Construct all possible combinations: ABCD, ABDC, BACD, BADC, etc, 24 possible combinations in all.

3) Number all 24 combinations as blocks from 1 to 24.

4) Choose random numbers (we used a table of random numbers in a statistical textbook). The numbers were from 0.0000 to 1.0000. We used the first two digits after the decimal limiter. If these fell between 1 and 24, a corresponding block was chosen. If they were above 24, they were ignored. Thus, blocks could be chosen in random order. Each block provided instructions for allocating the next four patients. Since the study would include all patients within the coming year, the exact number of patients to be randomized was unknown. Thus, more blocks were selected using the random number table than we expected to use when including patients.

5) The above procedure was performed before inclusion of patients began. The allocation of each patient was transferred to a note with one of the letters A, B, C or D. The note was then enclosed in a sealed opaque envelope. All envelopes were numbered sequentially, beginning with the number 1.

If this procedure is used in a matched design it would be called a block randomization. In a non-matched design, it is appropriate to simply call this procedure a complete randomization.

As can be seen, this complete randomization will produce group sizes that do not differ by more than one patient. However, due to drop-outs during the study, the differences in group size may increase.

In a two factor design, it is normally very important to have equal-sized groups. However, by using the two-factor analysis with a general linear model, equal group size was not essential.

Measurements

Patients were assessed at inclusion, six months and three years for intensity of combined head, neck or shoulder pain at the time of examination ("your pain now") with a visual analogue scale (VAS), a method shown reliable for both acute and long standing pain [132, 133].

CROM was on these occasions assessed by a medical laboratory technologist, registered nurse, or physical therapist. A cervical measurement system (CMS, Kuntoväline Oy, Oltermanninlie 00620, Helsinki, Finland) was used to measure lateral flexion, extension/flexion, and rotation. The CMS utilizes an inclinometer to measure

CROM in the sagittal and frontal planes, and a compass to measure cervical rotation. The CMS is both intra- and inter-tester reliable [134].

At the follow-ups, patients were asked to report the extent of sick leave due to WAD during the previous half-year [135]. Furthermore, at the six-month follow-up, patients were asked if they had received additional interventions from sources outside the control of this study. Personnel carrying out the measurements and interviewing patients were unaware of the patient’s group assignment.

Interventions

Active involvement and intervention (AII)

The active intervention is an active exercise protocol incorporating the idea of early and repeated movement based on Salter's work on continuous passive movement [122] and components consistent with McKenzie´s principles [123]. The active involvement and intervention consisted of two phases: 1) an initial phase given to all patients including information, postural control, and cervical rotation exercises; and 2) a second phase, if symptoms were unresolved, of evaluation and treatment according to McKenzie principles [123]. The same physical therapist (MR) treated all patients receiving the active intervention ensuring strict adherence to the protocol with no additional interventions. Treatment by the physical therapist was terminated six weeks after the initiation of AII or earlier if symptoms resolved.

In the initial phase, guidelines were provided to encourage safe, home exercising while teaching patients to identify and heed signs (new or increased symptoms) that might aggravate the condition. Patients were instructed to perform gentle, active cervical rotational movements from the neutral position, 10 times in one direction and 10 times in the opposite direction. Movements were performed to maximum comfortable range every waking hour. Patients were instructed to perform exercises in the sitting position if tolerated. The unloaded, supine position was recommended if the sitting position proved too painful. If rotation exercises were not tolerated, intervention was not discontinued but adjusted by either reducing the amplitude of the movements or by reducing the number of movements or both.

If symptoms persisted 20 days after the motor vehicle collision, the patients were then re-examined using a dynamic mechanical evaluation according to the McKenzie system. The McKenzie system classifies spinal-related disorders on the basis of the mechanical (such as CROM) and symptomatic (such as pain) responses to repeated movements, positions and activities derived from the history and assessment.

Treatment is predicated on these responses and emphasises self-care. The program consisted of movements such as cervical retraction, extension, flexion, rotation, or lateral flexion depending on which were beneficial and safe during the assessment.

Standard Intervention (SI)

SI consisted of written information on injury mechanisms, advice on suitable activities and postural correction. This leaflet was used by the Neck Injury Unit, Orthopedic Clinic, Sahlgrenska University Hospital, Göteborg, Sweden. The advice provided in this leaflet was to rest the neck during the first weeks following trauma and that a soft collar could provide comfort as well as prevent the neck from excessive movements. However, no data was collected on the utilisation of a collar. Furthermore, patients were instructed to perform active movements, two or three times daily a "few weeks" after trauma. The recommended movements were: elevation of shoulders, retraction of scapula, rotation of torso, lateral flexion of the head, rotation of the head, and combined flexion-rotation of the head.

Statistics

Statistics in study II-III

Analysis was by intention to treat. Differences in initial measurements between the four groups were analyzed with one-way analysis of variance (ANOVA) for continuous variables with equal variances between groups. Kruskal-Wallis one-way analysis of variance was used for continuous variables with statistically significant differences in variance between groups and for variables measured with an ordinal scale such as the VAS. Differences in variance between groups were tested using Bartlett's test for homogeneity of variance. The chi-square test was used for dichotomous variables such as gender.

At the 6-month and 3-year follow-up visits, changes over time in CROM and the extent of reported sick leave during the previous half year were analyzed with a two-way ANOVA. Friedmann's test was used for skewed data. Change in pain intensity (VAS) was calculated by the raw differences between baseline and follow-up measurements. Furthermore, raw differences were transformed to "improvement," "worsening," or "unchanged" and given the values +1, -1, and 0, respectively. For changes in pain intensity, ANOVA and Friedmann's test were applied to raw differences. Friedmann's test was also used to analyze transformed differences. Comparison in CROM between patients and unexposed individuals was made by Student's t test one sample.

To evaluate the effect of different interventions in restoring CROM compared with the unexposed individuals, two-way ANOVA was used.

All P values less than 0.05 were considered statistically significant. The computer program Epi Info version 6.04c (CDC, Atlanta,Georgia, USA) was used for one-way ANOVA, Kruskal-Wallis one-way analysis of variance, Bartlett's test for homogeneity of variance, chi-square test, and Student's t test. The computer program SAS version 8 (SAS Institute Inc., Cary, NC, USA) was used for two-way ANOVA and Friedmann's test.

Statistics in study IV

Analysis was by intention to treat. All costs are in Swedish Crowns (SEK) and in United States Dollars (USD) based on the exchange rate (7.9 SEK for 1 USD). Physical therapy treatment costs in the active intervention group were calculated by adding the patient fee of 80 SEK ($10) to the government insurance agency subsidy costs of 222 SEK ($28) giving a total of 302 SEK ($38) per treatment session. This was multiplied by the average number of physical therapy treatment sessions of 3.95, giving a total treatment cost of 1193SEK ($149) per patient in the AII group. We then estimated an average loss of production in connection with the treatment session at 3/8 of a day. Thus, estimated costs for production loss were 1024 SEK ($128) per day [136], adding up to 1577 SEK ($197) per patient in the AII group. The source of the treatment costs was the Swedish Council on Technology Assessment in Health Care, Report 102, October 1999.

The costs for each patient were compared in a two-factor analysis. Differences in initial measurements between the four groups (Table 1 in IV) were analysed with one-way ANOVA for continuous variables with equal variance between groups. Differences in variance between groups were tested using Bartlett's test for homogeneity of variance. Chi-square was used for dichotomous variables such as gender.

At the 6-month and 3-year follow ups, change in pain intensity, the extent of reported sick leave during the previous half-year and costs were compared between groups with a two-way ANOVA. Friedmann's test was used for skewed data.

All P values less than 0.05 were considered statistically significant. The computer program Epi Info version 6.04c (CDC, Atlanta) was used for one-way ANOVA. The computer program SAS version 6.11 (SAS-institute) was used for two-way ANOVA and Friedmann's test.

Results

Review (I)

In the literature search, 1726 studies were found. A minority, 56, were intervention studies that subsequently were further analyzed. Thirty-three were CCTs but 7 CCTs were not randomized and were thus excluded. The remaining 26 RCTs were quality assessed.

The interobserver reliability in quality assessment between the two independent reviewers was excellent (κ=1) for IMLB and good for DL (κ=0.76) and MAL (κ=0.74). There was no need to call upon the third reviewer to make a final decision.

The median scores (interquartile range) were for IMLB 2 (1-3), for DL 5 (4-6) and MAL 9.5 (8-12). Studies evaluating orthopaedic surgery as an intervention were often scored higher than studies investigating effects of chiropractic, drug therapy, physical therapy, or multimodal interventions.

The most prevalent shortcomings were:

- *Lack of blinding to patient and/or provider*
- *No eligibility criteria specified*
- *No reporting if treatment allocation was concealed*
- *No description of adverse effects*
- *Initial differences in groups at baseline*
- *Method of randomization not described or inappropriate*
- *Compliance unacceptable in all groups*
- *Not analysed by intention-to-treat*

The main finding of this review was the large number of PT articles on the subject. The interventions for acute WAD that have the strongest scientific support are: early physical activity, electromagnetic field therapy, and high-dose methyl-prednisolone therapy. Interventions for long-standing WAD with the strongest scientific support are: radiofrequency neurotomy, combined cognitive behavioral therapy with PT interventions, melatonin therapy, and coordination exercise therapy.

Intervention studies (II-IV)

Drop outs

Of 102 consecutive patients randomized, 5 patients were excluded because they did not fulfill the inclusion criteria. Of those patients, 2 had long standing neck pain and 3 had injury mechanisms other than motor vehicle collisions. Of the remaining 97 correctly included, 88 (91%) could be followed up at 6 months. Seventy-three (75%) participated in the 3-year follow-up visit.

Baseline differences

Four persons (4.1%) had no initial pain. Ten (10%) had low initial pain and three (3.1%) had high initial pain. The small differences between the four groups in age, sex, initial pain intensity, lateral flexion, flexion, extension, flexion plus extension, rotation, or total CROM were not statistically significant.

Treatment sessions

Of the patients receiving active intervention, 2 received one instruction/treatment session, 13 received two sessions, and 10 received three sessions. The remaining patients received more than three sessions. The mean number of instruction/treatment sessions in the active intervention groups was 3.95. Symptoms persisting more than 20 days were seen in 63% (27/43) of patients in the active intervention group. They were reexamined and treated as described previously. The numbers of patients receiving interventions from sources outside the control of this study did not differ statistically between the groups when comparing all four groups (Table 2, study II). None of those receiving treatment from sources outside the control of this study received treatment according to the McKenzie protocol.

Active involvement and intervention vs. standard intervention

Pain intensity decreased more in patients obtaining AII compared to those receiving SI (p at 6 months 0.0004-0.0009 and at three years 0.020-0.026). At three year follow up the need for sick leave was lower for patients receiving AII than in those receiving the SI (p=0.030).

Patients receiving an early AII had a total CROM similar to unexposed individuals at the 3-year follow-up visit. All other groups had decreased CROM compared with matched unexposed individuals. Thus, AII significantly increased the chances for regaining/retaining CROM as measured by comparing patients with unexposed healthy individuals compared to SI (p=0.032).

The importance of the time factor

The time factor, defined as initiating intervention immediately or with a delay of 14 days, did not by itself affect the outcome at either the 6-month or the 3-year follow-up visit.

Combining the intervention and the time factor in a two-way factorial design showed, at 6 months, an interaction between type of intervention and timing on the reduction of pain intensity (p=0.04) and on the improvement of cervical flexion (P=0.01). When active intervention was applied, it was better to receive it early. If standard intervention was given, it was better to receive it late. No interaction effect was found at the 3-year follow-up visit.

Comparison of the patients with individually matched unexposed control subjects showed a tendency to combined effect of timing and intervention on retaining/ regaining CROM at the 3-year follow-up visit. A trend was seen for CROM to be retained/regained when AII was received early and when SI was received late (p=0.053-0.063).

Health economics (IV)

Costs for an AII (also referred to as the active intervention) were lower at both 6 months (p=0.036) and 3 years (p=0.0008).

Discussion

Methodological aspects

Population

In 1993 and 1994 in an accident-prevention study in the southern half of Elfsborg County, the total number of motor vehicle collision associated whiplash injuries was estimated to be approximately 200 every year [137, 138] Because of cervical fractures, long standing neck pain, and other reasons, not all 200 would have been suitable for inclusion in the current study. Of the remaining patients who could be included, not all visited a physician early enough to be able to be randomized within 96 hours. It is estimated that the majority of all patients with a motor vehicle collision–associated whiplash injury in this area who fulfilled the inclusion criteria and sought a physician early enough were included.

It was estimated that the majority of patients exposed to whiplash trauma in this area fulfilling the inclusion criteria were included.

Sample size

The two-factor design not only divides patients into groups, but also calculates p-values using a two-way-ANOVA or Friedmann's test. In these statistical tests, all four groups are used simultaneously when calculating any p-value. Thus, the number used to calculate the p-values are not 16 versus 21, or 18 versus 18, but simply 73 (at the three year follow up). The two-factor design reduces the large numbers of patients required when several one-factor trials are used. Although an estimation of sample size was not done before data collection resulting significance levels indicate adequate sample size.

Outcome measures

The outcomes of pain intensity and CROM are considered relevant for the study of WAD whereby both pain and CROM are frequent symptoms. Sick leave was the only measure of disability. The study would have been enhanced by the addition of global measures of disability and well-being.

Statistical analysis

The last decade has seen a tendency from parametric to non-parametric statistical methods when analyzing VAS. However, opinions differ on comparing changes in VAS over time between groups. Some accept non-parametric methods applied to raw differences. Others state that common mathematical operations such as addition and subtraction are not defined in ordinal scales. Thus, raw changes in VAS were also transformed to –1, 0 or +1 as described previously. There is no international consensus in this matter, therefore changes in VAS are analyzed using the parametric ANOVA and the non-parametric Friedmann's test applied to both raw and transformed differences, although the authors prefer the latter. When comparing changes in VAS, the results from all three statistical methods favor active intervention.

Evaluating improvement of CROM in patients exposed to a whiplash trauma tells us if the patient is better but also utilizing a control group tells us if the patient is well. An unexposed control group is the only way to estimate pre-injury CROM in injured patients. This comparison has a clinical value and is the motivation for introducing unexposed individuals at the three-year follow-up.

Information to patients before inclusion was not controlled. If some patients randomized to SI prior to inclusion had been given advice similar to that given in AII, it would reduce our significant findings. This implies that differences between interventions might be even greater than those found in our study.

Generalisability

The study population was selected consecutively from a large area consisting of patients from both urban and rural populations. It was estimated that the majority of patients exposed to whiplash trauma in this area who fulfilled the inclusion criteria were included, thus establishing the generalisability of the sample.

The perspective of physical therapy

It has been stated that PT lacks an appropriate paradigm wherein, as Higgins and Titchen state, “assumptions, problems, research strategies, criteria and techniques are shared and taken for granted by the community”. A consensus was, however, reached on the definition of PT by the World Confederation for Physical Therapy (WCPT, 14th general meeting 1999), but has not been utilised internationally because of the diverse historical roots of the profession. That consensus is as follows: “Physical therapy is concerned with identifying and maximising movement potential, within the spheres of promotion, prevention, treatment and rehabilitation. Physical therapy involves the interaction between physical therapist, patients or clients, families and care givers, in a process of assessing movement potential and in establishing agreed upon goals and objectives using knowledge and skills unique to physical therapists.”

As a physical therapist trained and licensed in Sweden, I have adhered, whenever possible, to the Swedish physical therapy concept. Pehr Henrik Ling, considered the “father” of Swedish gymnastics and medical gymnastics, defined physical therapy in the early 19th century as “the means by which the human being, either through oneself or through the help of movement and exercise, tries to minimize or overcome the suffering which has developed in one’s body due to abnormal circumstances”.

The modern Swedish definition of physical therapy was adapted by the scientific committee and the board of the Swedish Association of Registered Physical therapists in 1997:
“*The subject of physical therapy encompasses human movement with respect to the ability to comprehend, control and utilise the body to adequately meet the demands of a physical and social environment. The basis consists of movement science, comprising biomechanical, physiological and psychological factors and perspectives of movement and the specific dysfunctions of movement caused by disease or injury.*
Interaction and teaching through information and instruction are vital components of the subject. Physical therapy practice entails prevention, examination and treatment of the functional impairments limiting or threatening to limit human movement capacity.”

According to Carr and Shepherd et al [148], “physical therapy is an applied science and as such depends on the extrapolation of information from scientific research”. The defined body of knowledge forming the theoretical basis of PT that could be called movement science, encompassing the fields of biomechanics, motor learning, muscle biology, neurophysiology, cognitive psychology, and human ecology.

This thesis will attempt to provide a background of WAD and their treatment from a PT perrspective. WAD presents the physical therapist with a complex task whereby intervention must be aimed at prevention of impairments, functional limitations, disability and further injury including the promotion and maintenance of health, quality of life, and fitness in all patients subjected to whiplash injury while avoiding the dualistic split that symptoms must be either in the body or in the mind.

Whiplash injury without symptoms – WAD 0

A person exposed to a whiplash trauma initially not reporting symptoms may still bear a whiplash injury that might express symptoms later. At present, it is impossible to confirm or rule out an association between the trauma and delayed manifestations of WAD. Thus, we have chosen to include all patients exposed to a whiplash trauma (caused in an MVC) attending the health care system. In our study, four patients were initially without symptoms (WAD 0) and three of these later developed manifestations. Interestingly, the only person not developing delayed manifestations belonged to the group receiving early AII while the three others received SI. Due to the appearance of delayed symptom debut in some patients, it is this author´s view that patients exposed to cervical trauma in an MVC should be provided with adequate information on the importance of early return to activity and movement should symptoms arise. They should also be given an opportunity to consult a physician and/or physical therapist.

Possible mechanisms of active involvement and intervention

The most important elements of the AII were the high frequency and intensity of self-mobilization and the use of the McKenzie protocol for patients with unresolved symptoms. In short, the SI emphasizes caution, whereas the AII encourages active movement. Furthermore, patients in a study by Friedrich were more likely to comply with and properly execute physical exercise when monitored by a PT. Not surprisingly, there was also a strong correlation between correct exercise and reduction of pain [139].

Since pain lacks an external convention of reference, it allows considerable room for interpretation and thus, the importance of cognitive processes in the pain experience is great [140]. Left unsupervised, an exaggerated negative response to pain may develop. The resulting pain-related fear is a strong factor in the development of illness behaviour, (an unfortunate, but often used term) [140-142]. Prescribing immediate exercise within comfort limits may alleviate fear of serious injury [143, 144]. Continued supervision during the first weeks would provide ongoing reassurance of a satisfactory outcome, thus promoting wellness behaviour. This interaction with a therapist prescribing activity was unavailable in the standard intervention.

The organic aspect of WAD is dealt with by utilizing rotational exercises in the acute stage and repeated movements or positions based on the McKenzie evaluation in the sub-acute stage. Movement encourages regional blood flow and facilitates removal of exudates, thus allowing healing to occur by aiding nutrition of joint structures [73, 145].

It should be pointed out that neither fear-avoidance behaviour nor regional blood flow was measured in this study.

Why cervical rotation?

As stated previously, the original motivation for cervical rotation was to load the joints and optimise healing and cartilage regeneration according to the findings of Salter using continuous passive movement [128]. Furthermore, studies indicate that upper limb pain and paraesthesiae in patients with WAD may arise from hyperalgesic cervical or brachial plexus nervous tissue [28, 30]. Cervical spine rotation addresses this involvement by mobilizing the nerve structures on the contralateral side thus preventing scar tissue and adhesions causing later dysfunction. Rotation avoids the longitudinal stress on the neural axis caused by flexion and lateral flexion [146]. Mobilisation may also affect possible inhibition of intraneural microvascular blood flow due to compression [147].

Summary and Conclusions

In summary, much has occurred since the Quebec Task Force issued its report in 1995. Now, as then, fundamental questions remain regarding WAD. We do have, however, a considerably better idea today which damaged structures may lead to WAD, thus enabling improved treatment, diagnosis and prevention.

Some of the more interesting and important developments in understanding musculoskeletal disorders including WAD has been the discovery of the importance of factors other than tissue damage and pain for the outcome of WAD. These factors include patient self-efficacy, coping strategies, fear-avoidance beliefs and psychological distress. This will hopefully have an effect on the acute and long-standing symptoms of WAD where there is little evidence for effective treatment.

The multitude of symptoms and the high costs of WAD present an enormous challenge to health care and societies throughout the world. The findings of this thesis have shown that an active involvement and intervention from a physical therapy perspective focusing on early involvement and movement complemented by mechanical diagnosis and therapy according to McKenzie is effective in reducing symptoms and costs for patients with WAD. This fulfils one of the high priority questions of the QTF in 1995 concerning the efficacy and cost-effectiveness of common therapeutic interventions for WAD.

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