Acceleration-deceleration injuries: 'Whiplash Syndrome'

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'Whiplash syndrome' is a term commonly used to describe hyperflexion, hyperextension and other injuries to the spine, and, in particular, to the cervical region. It is not a universally accepted term, however, is commonly used in medical and legal settings. Cailliet (1991) reports that the term' 'whiplash' was first coined by Dr. Harold Crowe (1928), who noted that acceleration-deceleration resulting from an external impact had a 'lashlike effect' in the neck and upper body. The term has since come to be commonly (and often inappropriately) used to describe a variety of tissue insults, which produce a collection of symptoms resulting from mechanical and tissue damage. The term 'acceleration-deceleration injury' or more specific terms detailing the exact nature of the injury are better substituted for the more controversial term 'whiplash' as it is ill-defined and non-specific. These types of traumas are most often associated with automobile collisions, however, they can also result from falls, bicycle accidents, horse riding injuries and a host of other sporting and recreational occurrences. For simplicity, the automobile collision is the point of reference for this article, although any of these sources of injury could easily be the focus of discussion.

Types of injuries

The type of injuries acquired will depend upon the nature of the accident and the forces placed upon the body. The forces placed upon the cervical spine, for instance, will differ tremendously when the automobile carrying the person impacts another object in front of the car (linear translation, primarily hyperflexion) compared to the car being impacted from the rear (linear translation, primarily hyperextension) or from the side (lateral translation). (Chaitow & DeLany 2000) Other components are involved when the car holding the person is placed into a spin upon impact (rotational), or when compressive or tractional forces result, or by a combination of any of these. (Cailliet 1991) Additionally, the direction the person is looking when the vehicle impact occurs will, in part, determine which tissues are damaged and their extent of injury.

Of great importance is the degree to which the patient is restrained by the seat belt system and the deploying airbags. It should also be held in mind that seldom are these injurious movements singular (such as pure hyperflexion), as forces may create multiple movements or rebound phenomenon of the head, neck, torso and extremities.

In reality, a multitude of physical traumas can manifest in an acceleration-deceleration injury as a series of collisions actually occur when a motor vehicle is involved in a crash. When a vehicle collides with an object (another vehicle, tree, etc.) in front of the vehicle, the bodies of the passengers continue to move at the pre-crash speed. If a person is properly restrained, his/her body will impact against the restraining device (seat belts or other restraint) very soon after the primary collision. This impact with the restraining device may itself cause damage to the shoulder, neck, pelvis, chest or other body parts which it crosses, however, the restraint will usually prevent the entire body from moving further forward. The head and neck or extremities may continue moving in a forward direction until they reach their respective limits or until they impact another object. The mandible may then continue moving forward (including dislocation) until it reaches

its mobility limits as determined by muscles and ligaments, which may be damaged in the process. If the body is not restrained on initial vehicular impact, the entire body will continue moving until it collides with the interior of the vehicle or with the ground or another object outside the vehicle. In any case, and lastly, the internal organs will eventually impact against bony structures which enclose them (brain and skull, lungs and ribs, etc.), which can be lessened somewhat by the degree of proper restraint by seat belts, airbags, and padding.

Restraining devices, when fitted and used properly, reduce the chance or degree of these multiple impacts and, at the same time, reduce (as much as possible) potential injury by the restraining device itself. The design of the vehicle, airbags, and snug-fitting seatbelts (with shoulder harnesses) all assist in protecting the adult body during the crash. The degree of potential impact between the internal organs and the skeleton can be reduced by always tightly adjusting the seatbelts, which lowers the body's overall deceleration in the event of a crash. (Weber 2000) Additionally, distributing the load of impact as widely as possible and onto the strongest body parts (in adults, primarily the shoulder and pelvis, and, secondly, the chest) optimally reduces impact injury. The special needs of child passenger restraints are discussed later.

While an acceleration-deceleration impact injury may produce trauma in various body regions, for the purposes of this article, only the cervical region is considered. Damage to discs, ligaments, zygapophyseal (facet) joints, joint capsules and vertebrae can be minor or extensive. The types of vertebral fractures range from hairline fractures to more serious wedge fractures (vertebral bodies are crushed) and slice fracture (segment of the vertebra is avulsed). Discs may abruptly herniate into the nerve roots or spinal cord space, requiring immediate surgery, or the process of herniation may take place over several months, resulting in a delayed onset of symptoms. Though one might assume that a patient with an injury of this nature would be under the care of a physician, this is not necessarily true, and caution upon initial examination should always be exercised. Damage to the deeper ligaments is not easily determined by an office or emergency room examination alone.

Additionally, disc degeneration may be progressive. It is, therefore, best to work cautiously (particularly regarding active and passive movements of the injured neck) until determination has been made by a qualified physician regarding the extent of ligamentous or disc damage. If excessive or aggressive movements, even in regards to stretching soft tissues, are placed on damaged ligaments or discs, further tissue damage could result.

Chronic pain is often the result of acceleration-deceleration injuries. A number of soft tissues within the cervical spine are innervated with nociceptors and are, therefore, capable of transmitting pain. These include the anterior and posterior longitudinal ligament, annular fibers of the intervertebral disc, the dura of nerve roots, zygapophyseal (facet) joint capsules, intervertebral ligaments, extensor and flexor musculature, and the precervical fascia. Massage therapists, though working directly and primarily with the muscles and fascia, indirectly affect these other structures as well.
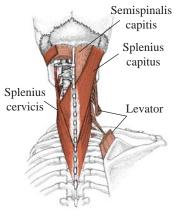
Potential muscular trauma

When forces are placed upon the muscular tissues, such as occurs in an acceleration-deceleration injury, the tissues may be torn. The tearing of muscular tissues can be minor or extensive, however, either will likely result in immediate spasm of the muscles. The reflexive spasms and associated edema serves to reduce blood flow to the tissues as well as to splint the area to reduce potential movement, thereby allowing the connective tissue to repair the injury site without being further torn by movement. Muscular spasm is a natural and normal occurrence and, along with a normal inflammatory process, is important in the healing process. However, when spasm and inflammation are prolonged into a chronic state, further sensitization and facilitation of the central nervous system can result in additional neuromuscular dysfunction, including changes in proprioception. (Chaitow & DeLany 2000) Additionally, when disc and ligamentous damage is extensive, muscular spasm may serve to stabilize the region. Removal of this stabilizing, splinting affect (through massage and other means) may increase neurological symptoms and increase the risk of further disc damage. Understanding the degree and type of

damage as well as being attentive to the body's reaction to release (Does it quickly re-spasm? Is it more painful after treatment?) can serve to help guide the appropriate course of therapy.

All cervical muscles are at risk of injury in an acceleration-deceleration injury. The degree and extent of injury is determined by a multitude of factors, including the pre-existing condition of the tissues, angle of vehicular impact, speed of the vehicle and/or the object(s) with which it collides, and the degree of restraint (seat belt, airbag, etc.). Muscles in the posterior neck region that are vulnerable to injury include trapezius, splenii, semispinalis cervicis and capitis, multifidus, rotatores, erector spinae and the suboccipital muscle group. Anteriorly, the sternocleidomastoid, longus colli and longus capitis are of primary concern, although other anterior muscles (such as those attaching to the hyoid bone) may also be injured. Laterally, the scalenii are vulnerable. The muscles of mastication as well as the temporomandibular joint may also be injured, though complaints of pain in this region are often delayed.

It is important that a properly trained and skilled myofascial clinician be incorporated in the examination and documentation procedure. The location of active and latent trigger points should be charted as well as any referred patterns associated with the patient's pain. Ischemic and hypertonic myofascial tissues associated with loss range of active and passive motion, and/or those producing pain during movement should be documented at the onset of treatment as well as periodically throughout the subsequent therapy sessions.

An article of this length cannot possibly discuss each of these cervical muscles, all of the chest, back, jaw and upper or lower extremity muscles that may potentially be involved. Instead, the region of the suboccipitals has been selected and components of its importance in this type of injury are discussed below. Each muscle is deserving of this type of attention, the quality of which is dependent upon the clinicians knowledge base and skill level.

Semispinalis capitis
Splenius capitus
Splenius cervicis
Levator

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Suboccipital muscle group

The suboccipital muscles are nested directly beneath the occiput in the deepest layer of posterior muscle tissues. These four small muscles (rectus capitis posterior minor and major, obliquus capitis superior and inferior) provide fine motor control of head position. They also work in co-ordination with other head and neck muscles to provide counteractive positioning of the head in opposition to type I movements of the lower functional unit of the cervical region (C3-C7). When the four muscles simultaneously contact on one side only (unilateral contraction), slight lateral flexion of the head is produced with associated ipsilateral head rotation accompanied with head extension – the three composite movements of the upper cervical unit (type II). Bilateral contraction of all suboccipital muscles produces extension of the cranium and translation of the cranium anteriorly on the atlas. However, when acting alone, each of these muscles individually produces a fine control of stabilization or movement of the cranium on the atlas, the atlas on the axis or retraction of the dural tube within the spinal canal. This stabilizing (rather than movement producing) affect is undoubtedly linked to proprioceptive and balancing mechanisms.
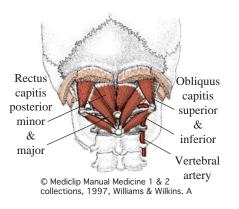
In Clinical Application of Neuromuscular Techniques, Chaitow & DeLany (2000) discuss the unique and important characteristics as well as endangerments in the suboccipital region. They note,

"Three of the four suboccipital muscles (all except RCPMi) form the suboccipital triangle. The vertebral artery lies relatively exposed in the lower aspect of this triangle and is to be avoided when pressure or friction is applied to this area, especially when the tissues are placed on stretch. The greater occipital nerve courses through the top of the triangle before penetrating the semispinalis capitis and trapezius muscles on its way to supply the posterior external cranium. The nerve may also penetrate obliquus capitis inferior.

Ideally, flexion (10º) and extension (25º) of the head occur between the occiput and atlas, as well as translation of the head upon the atlas. The degree of rotation or lateral flexion is only slight since more would be undesirable at this particular joint due to the risk of unwanted spinal encroachment of the odontoid process (the dens) on the spinal cord. The vertebral artery lies on the superior aspect of the lateral masses of the atlas and might also be crowded by excessive movements of the atlas. The transverse ligament retains the dens in position while allowing the atlas to rotate around it. The ligament articulates with the posterior aspect of the dens while the atlas articulates with its anterior surface.

Faulty head/neck mechanics, such as forward head posture, place high demand on the suboccipital muscles to maintain the head's position, while simultaneously crowding the space in which they operate, often physiologically shortening them in the process. ...... While the motor function of these four muscles is primarily to extend the head and to translate and rotate the head, their dysfunctions include involvement in the all-too-common forward head position. A number of researchers have shown that dysfunction of these small muscles in general, and RCPMi in particular (often resulting from whiplash), leads to marked increase in pain perception as well as reflex irritation of other cervical as well as jaw muscles (Hack et al 1995, Hallgren et al 1994, Hu et al 1995). An ultimate aim of postural compensation is to maintain the eyes and ears in an approximately level position. When the cranium is posteriorly rotated, the suboccipital group's role in sustaining this position is substantial. A forward head position involves a posteriorly rotated cranium which has then been brought to a position where the eyes and ears are level with the horizon. The suboccipital space is crowded and the muscles significantly shortened, which often leads to trigger point formation. The contractures associated with trigger points may then assist in maintaining the shortened position without excessive energy consumption."

Of particular interest among this group is the rectus capitis posterior minor, which courses from the occipital bone to a tubercle on the posterior arch of the atlas. Chaitow & DeLany (2000) continue, "While

Rectus capitis posterior minor & major — Obliquus capitis superior & inferior — Vertebral artery

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most texts note that this muscle extends the head, recent research (Greenman 1997) has shown it to contract during translation of the head and to tense a connective tissue attachment (fascial bridge) to the dura mater which retracts the dural tube and prevents it from folding onto the spinal cord. RCPMi may play a small part in head extension and translation but ...... its main role would seem to be proprioceptive rather than motor. Recent research (Hack et al 1995) has demonstrated that a connective tissue extension links this muscle to the dura mater which provides it with potential for influencing the reciprocal tension membranes directly, with particular implications to cerebrospinal fluid fluctuation because of its site close to the posterior cranial fossa and the cisterna magna. It could also influence normal functioning of the vertebral artery and the suboccipital nerve which could further aggravate any hypertonus of the region." These and other concepts regarding this muscle are discussed at length in Clinical Application of Neuromuscular Techniques, Vol. 1, the upper body.

Rectus capitis posterior major courses from the occipital bone to the spinous process of C2 (axis). It serves to extend the head as well as provide ipsilateral head rotation. Chronically placing the neck in flexion or extension stresses these muscles while producing hypertonicity and trigger point activity. Referred pain from triggers in this and other suboccipital muscles has poor definition, radiating into the lateral head from the occipital region to the eye.

Obliquus capitis superior runs from the superior surface of the transverse process of C1 to the occipital bone and provides extension of the head and minimal lateral flexion of the head. Indications for treatment include

loss of suboccipital space, deep-seated posterior neck pain, headache wrapping around the side of the head to the eyes and an unstable atlas, especially sidebent cranially.

Obliquus capitis inferior attaches the spinous process of C2 to the inferior aspect and dorsum of the transverse process of C1. It provides ipsilateral rotation of the atlas and, therefore, the cranium. Indications for treatment include loss of rotation, such as looking over shoulder, as well as unstable atlas, especially sidebent inferiorly with rotation.

Practitioners who commonly friction beneath the occipital bone should remain consciously aware of the course of the vertebral artery and avoid compression or friction of this structure. This is particularly important in cases where the artery may be predestined to vulnerability (such as aortic dissection or dissecting aneurysm). Additionally, awareness of the rectus capitis posterior minor's attachment to the dural tube precludes the use of excessive pressure or aggressive friction of this muscle in order to avoid tearing this delicate attachment.

Protecting child passengers

The immature bodies of children have special protective needs when being transported in motor vehicles. The protective needs change as the child's body grows. In the early stages, before bones, ligaments and muscles offer enough support, rear-facing car seats help prevent cervical, head and spinal cord trauma. As the body matures sufficiently to better withstand the severe tensile forces associated with deceleration, forward-facing restraints can be employed, first as a car seat (strapped in with built-in body restraints) then as a booster seat (using vehicle's shoulder-lap belt).

The type of restraint needs to be age-appropriate and must be re-evaluated as the child's body matures. An adult seat belt can be safely used without other restraining devices when 5 conditions are met simultaneously:

1. The child can sit with lumbar spine and upper buttocks fully against the seatback.

2. The knees bend at a 90º angle at the seat edge.
3. Shoulder belt fits across the shoulder.
4. The lap belt fits over the thighs or bony pelvis.
5. The child is mature enough to sit reasonably still during the ride. (Sachs & Tombrello 2000)

Most drivers are familiar with the use of car seats for young children. When the child matures to (about) 4 years old and 40 lbs and the child's height or weight surpasses the upper end limits recommended by the manufacturer (instructions should be carefully read), many adults erroneously conclude that the child should be advanced to adult seat belts. Actually, the child's body at that stage is still too small to properly fit the adult belt. Proper placement of the seat belt includes the lap portion of the belt fitting snugly across the bony portion of the pelvis and with the shoulder strap fitting across the midsternum and crossing the shoulder about half way between the neck and the arm. Upon impact, the lap belt rides up into the fleshy abdomen and the shoulder strap onto the anterior cervical region of a child's body, often resulting in serious (including spinal cord) injuries. (Weber 2000) Equally or more dangerous is the practice of placing the shoulder portion behind or under the child's arm to avoid irritation to the neck. This positioning results (upon impact or even during hard braking) in the child submarining under the belt or being ejected over it, leading to serious injury or fatality. The child who cannot achieve a proper fit of both lap and shoulder belt (see above five point list) should ride in a booster seat specifically designed to adapt the adult seat belt to the child's body.

Weber reports (2000), 'A lap belt that is placed or rides up above the hips can intrude into the soft abdomen and rupture or lacerate internal organs (Rouhana 1993, Rutledge et al 1991). Moreover, in the absence of a shoulder restraint, a lap belt worn high can act as a fulcrum around which the lumbar spine flexes, possibly causing separation or fracture of the lumbar vertebrae in a severe crash. .... A belt-positioning booster raises the child so that its body geometry is more like that of an adult and helps route a lap/shoulder belt to fit that body size.'

The National Highway Traffic Safety Administration (NHTSA 2000) is responsible for developing a

comprehensive 5-year strategic plan to reduce deaths and injuries caused by failure to use the appropriate booster seat in the 4 to 8 year-old age group. NHTSA notes that in February 2000 they launched their 'Don't Skip a Step national booster seat campaign to educate parents about the risks of improperly positioned adult seat belts and the effectiveness of belt-positioning booster seats for children ages 4 to 8 years.'

Proper installation of a child restraint system is critical to its protective features. Seat belt systems in automobiles vary (sometimes 5-6 different types of seat belts in one automobile). It is suggested that each booster be checked by a trained professional for proper installation and for tips on its appropriate use. This can often be achieved at a local fire station.

The technology of restraining the occupants in motor vehicles (and particularly infants and children) is ever changing and advancing to improve the possibilities of survival of impact without serious injury or fatality. It is important that the latest information be accessed and passed on to the public (especially parents and caregivers) through health care providers and educators. The following contact sources are provided to assist in this task. These websites are packed full of information regarding these as well as other safety issues. There are many other websites available as well, many of which can be found by a topic search.

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Contact Resources:

Insurance Institute for Highway Safety - www.highwaysafety.org

National Highway Traffic Safety Administration - www.nhtsa.dot.gov

University of Michigan Transportation Research Institute - UMTRI Research Review (newsletter-$35/yr subscription)-www.umtri.umich.edu

About the author: Judith DeLany is a licensed massage therapist. professional speaker regarding myofascial pain syndromes and an associate editor and contributing author for Journal of Bodywork and Movement Therapies. (Elsevier) Ms. DeLany and Dr. Leon Chaitow have co-authored Clinical Application of Neuromuscular Techniques (Vol 1, the upper body, 2000, and Vol 2 the lower body, 2002), which serve as instructional textbooks for the development of palpation, evaluation and treatment skills. Ms. DeLany has received numerous awards and recognition for her contributions to the field of massage therapy, including Massage Therapist of the Year (1999) by the Florida Chiropractic Association. Her continued work focuses on education in all health care fields to include manual techniques as a practical treatment for many causes of chronic pain.