Stabilizing Effect of Pre-Contracted Neck Musculature in Whiplash

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FROM ABSTRACT:

Study Design.
This study investigated the effect of neck muscle pre-contraction in aware occupants in whiplash.

Head angulation relative to T1 and facet joint capsular ligament distractions were compared between aware and unaware occupants.

Objective.
To quantify changes in facet joint capsular ligament distractions between aware occupants with pre-contracted neck muscles and unaware occupants with reflex muscle contraction.

Summary of Background Data.
Clinical studies have reported that patients aware of the impending impact had decreased symptom intensity and faster recovery after whiplash.

To date, no study has investigated the effects of pre-contracted neck musculature on localized spinal soft tissue distortions in whiplash.

Methods.
Aware occupants with pre-contracted neck muscles and unaware occupants with reflex muscle contraction in whiplash were simulated using a validated computational model.

Results.
Pre-contraction of neck muscles in aware occupants resulted in 63% decreased maximum head angles, elimination of cervical S-curve, and up to 75% decrease in maximum facet joint capsular ligament distractions.

Conclusions.
Occupants aware of an impending whiplash impact with pre-contracted neck muscles can markedly reduce overall head-neck and spinal motions.

It is our theory that this would reduce whiplash injury likelihood.
THESE AUTHORS ALSO NOTE:

The abnormal S-shaped cervical spinal curvature (flexion at upper and extension at lower cervical levels) caused by a rear-end motor vehicle collision, “results in nonphysiologic facet joint motions.”

A prior study has shown that “awareness of the impending impact resulted in significantly lower frequency of multiple symptoms and intensity of headache pain.” [Sturzenegger M, DiStefano G, Radanov BP, et al. Presenting symptoms and signs after whiplash injury: the influence of accident mechanisms. Neurology 1994;44:688-93.]

A randomized clinical study of whiplash patients also found that “unpreparedness was associated with poor recovery.” [Hendriks EJ, Scholten-Peeters GG, van der Windt DA, et al. Prognostic factors for poor recovery in acute whiplash patients. Pain 2005;114:408-16.]

“These studies highlighted the ability of the aware occupant to reduce the likelihood of injury by taking some preventative action before impact (e.g., contracting neck muscles).”

In contrast to being aware prior to collision, “reflex contraction [which occurs when caught by surprise] decreased cervical spinal segmental kinematics by a maximum of only 19%.”

It is thought that whiplash injury occurs during the abnormal S-shaped cervical curvature and nonphysiologic lower cervical facet joint motions. The maximum S-curvature occurs at approximately 76 ms for 9-km/hr [5.5 m/hr] rear impacts.

These authors used a head-neck computer model for whiplash simulation, which had been validated in 2004. Aware and unaware occupant simulations were subjected to 10.5-km/hr [6.5 m/hr] rear impacts. “The model was comprehensively validated against human volunteer, human cadaver, head-neck complex, and isolated cervical column whiplash experimentation.”

RESULTS

The unaware occupant demonstrated an S-shaped cervical spinal curvature, overall extension of the head and neck, and rebound of the head due to neck muscle contraction.

The aware occupant did not demonstrate the S-shaped spinal curvature, and maximum extension angulation of the head relative to T1 was considerably less in the aware occupant compared to the unaware occupant.
Head extension was 82.7° in the unaware occupant, and only 30.5° in the aware occupant with pre-contracted neck muscles. [This represents a 64% reduction in head extension from being aware vs. being caught by surprise.]

“Pre-contraction of neck muscles considerably and consistently decreased maximum capsular ligament distraction magnitudes at C4-C5 through C6-C7 spinal levels by an average of 63%.” [Important] At C6-C7, capsular ligament distraction magnitudes were decreased by 75%.

DISCUSSION

These authors note that 10.5-km/hr [6.5 m/hr] rear impacts exceed the level that is “unlikely to result in significant injury.” [IMPORTANT: this indicates that 6.5 m/hr rear impact is a level that produces injury.]

These authors note that the reason some are injured at low impacts and others are not injured at high impacts is because “a number of occupant- and crash-related factors influence whiplash injury likelihood and outcome.”

These authors cite references that document variables that affect whiplash injury, including:
1) Gender (5 references)
2) Age (2 references)
3) Cervical posture (2 references)
4) Head restraint backset (2 references)
5) Head position
6) Awareness of the impending impact

“From a biomechanical standpoint, impact severity is an important factor in determining patient outcomes after automotive rear impacts. However, it cannot be applied as an exclusive factor in determining whether an occupant will be injured or the extent of injury in a specific rear impact collision.” [Very Important]

This study “demonstrated the ability of pre-contracted neck musculature to stabilize the head-neck complex during whiplash and reduce spinal motions and soft tissue distortions.”

“Our hypothesis is that decreased tissue distortion, particularly for facet joint capsular ligaments, correlates with a decreased likelihood of injury, nociception, and allodynia.”

“The ability of an aware occupant to decrease facet joint distractions by up to 75% will markedly reduce the possibility of injury under identical levels of whiplash loading.”
“Although head restraints were introduced into passenger vehicles to reduce the likelihood of whiplash injury, these devices have had a limited effect on patient outcomes after automotive rear impacts. A possible explanation for limited head restraint effectiveness is that the head-neck complex sustains nonphysiologic kinematics (retraction leading to S-shaped cervical curvature) before head restraint contact unless the head restraint is oriented in an optimum position.”

“Adjustable head restraints are often not positioned correctly to protect the head-neck complex during whiplash.”

“Present results demonstrated that timing of neck muscle contraction is critical to reducing spinal soft tissue distortions that may lead to whiplash injuries.”

“Aware occupants with pre-contracted neck muscles demonstrated markedly reduced head-neck motions and facet joint capsular ligament distractions along with elimination of cervical S-curve curvature under identical levels of rear impact loading.”

Delayed muscle contractions for the unaware occupant results in “considerably increased soft tissue distortions in the facet joints and a corresponding increase in whiplash injury likelihood.”

“Results of the present study demonstrated a 60% decrease in maximum head extension in the aware occupant,” which directly reduces distortion of soft tissues such as facet joint capsular ligaments and intervertebral discs.

CONCLUSION

“The present study demonstrated that occupants aware of the impending impact with pre-contracted neck muscles can markedly reduce overall head-neck and spinal motions.”

“In particular, facet joint capsular ligament distractions were decreased by up to 75% in the aware occupant.”

“Because of the role of facet joints in the perception and persistence of whiplash pain, it is our theory that decreased ligament distractions in lower cervical joints will lead to markedly reduced whiplash injury likelihood.”

KEY POINTS FROM AUTHORS:

1) “Pre-contraction of neck muscles in aware occupants eliminated cervical S-curve curvature, decreased maximum head-neck extension magnitude by 63%, and decreased maximum facet joint ligament distractions between 53% and 75%.”

2) “Because of decreased soft tissue distortion, it is our theory that whiplash injury likelihood is markedly decreased in occupants aware of the impending impact.”
KEY POINTS FROM DAN MURPHY

1) Clinical studies indicate that patients aware of the impending impact have decreased symptom intensity and faster recovery after whiplash.

2) Pre-contraction of neck muscles in aware occupants results in 63% decrease in head extension, a 75% decrease in maximum facet joint capsular ligament distractions, and elimination of cervical S-curvature.

3) Occupants aware of an impending whiplash impact with pre-contracted neck muscles can markedly reduce overall head-neck and spinal motions, and thereby significantly reduce neck injury.

4) The abnormal S-shaped cervical spinal curvature (flexion at upper and extension at lower cervical levels) caused by a rear-end motor vehicle collision, “results in nonphysiologic facet joint motions.”

5) Awareness of impending whiplash-causing impact results in significantly lower frequency of multiple symptoms and intensity of headache pain.

6) During whiplash trauma, being caught by surprise is associated with poor recovery.

7) Whiplash injury occurs during the abnormal S-shaped cervical curvature, with nonphysiologic lower cervical facet joint motions.

8) A 6.5 m/hr rear impact collision is a level that produces injury.

9) For the unaware occupant subjected to a 6.5 m/hr rear-end collision, head extension averaged 82.7° which is significantly beyond a normal physiological range of motion.

10) For the aware occupant subjected to a 6.5 m/hr rear-end collision, head extension averaged only 30.5°, which is within the normal physiological range of motion.

11) “Pre-contraction of neck muscles considerably and consistently decreased maximum capsular ligament distraction magnitudes at C4-C5 through C6-C7 spinal levels by an average of 63%.” At C6-C7, capsular ligament distraction magnitudes were decreased by 75%. [Important]

12) Some vehicle passengers are injured at low impacts and others are not injured at high impacts because “a number of occupant- and crash-related factors influence whiplash injury likelihood and outcome.”
13) Impact severity “cannot be applied as an exclusive factor in determining whether an occupant will be injured or the extent of injury in a specific rear impact collision.” [Very Important]

14) Pre-contracted neck musculature reduces spinal motions and soft tissue distortions; decreased tissue distortion, particularly for facet joint capsular ligaments, which decreases the likelihood of injury and pain.

15) “The ability of an aware occupant to decrease facet joint distractions by up to 75% will markedly reduce the possibility of injury under identical levels of whiplash loading.”

16) Head restraints are poor in reducing injury from rear impacts because the nonphysiologic S-shaped cervical curvature occurs before head restraint contact.

17) “Adjustable head restraints are often not positioned correctly to protect the head-neck complex during whiplash.”

18) “Results of the present study demonstrated a 60% decrease in maximum head extension in the aware occupant,” which directly reduce distortion of soft tissues such as facet joint capsular ligaments and intervertebral discs.

19) “The present study demonstrated that occupants aware of the impending impact with pre-contracted neck muscles can markedly reduce overall head-neck and spinal motions.”

20) “Because of the role of facet joints in the perception and persistence of whiplash pain, it is our theory that decreased ligament distractions in lower cervical joints will lead to markedly reduced whiplash injury likelihood.”