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Cervical collars and braces in athletic brachial plexus injury and excessive cervical motion prevention: a review of the literature

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A review of the literature was conducted to find publications relating to neck collars / rolls and prevention of sports injury, particularly burners and other cervical spine injuries, as well as in preventing excessive motion of the cervical spine. MEDLINE (1970–2005), Cinahl (1982–2005), Alt Health Watch (1990–2005), AMED (1995–2005), and the Index to Chiropractic Literature (1985–2005) databases were searched. To date there has been very little documented study into the ability of cervical collars/neck rolls to prevent excessive motion of the cervical spine or to prevent injury. Neck rolls/braces are capable of limiting cervical hyperextension under laboratory conditions, but the same can not be said for their ability to limit lateral flexion. Only one empirical study could be identified that looked at the ability of a collar to prevent burners and other neck injuries in athletes. Further laboratory and on-field studies are clearly needed.
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KEY WORDS: chiropractic, cervical spine, collar, burner, neck injury

Une revue de la littérature a été réalisée dans le but de trouver des publications traitant des colliers cervicaux ou des rotations de la tête et de la prévention des accidents du sport, en particulier les brûlures et d'autres blessures relevées au niveau de la colonne cervicale. Les bases de données suivantes ont été consultées : MEDLINE (entre 1970 et 2005), Cinahl (entre 1982 et 2005), Alt Health Watch (entre 1990 et 2005), AMED (entre 1995 et 2005) et l'Index to Chiropractic Literature (entre 1985 et 2005). À ce jour, il existe très peu d'études documentées sur la capacité des colliers cervicaux ou des rotations de la tête à prévenir les mouvements excessifs de la colonne cervicale ou les blessures. Les colliers cervicaux et/ou minerves sont capables de limiter l'hyperextension cervicale en conditions de laboratoire, mais on ne peut pas en dire autant quant à leur aptitude à limiter la flexion latérale. Seule une étude empirique a pu être identifiée comme étudiant la capacité d'un collier cervical à prévenir les brûlures et d'autres blessures relevées au niveau du cou, chez des athlètes. Des études supplémentaires menées en laboratoire et sur le terrain sont manifestement indispensables.
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MOTS CLÉS. Chiropratique, colonne cervicale, collier cervical, brûlure, blessure au cou.

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Introduction

"Burners", also known as "stingers" or brachial plexopathies are a common traumatic brachial plexus or lower cervical nerve root injury in contact/collision sports such as football, hockey, lacrosse, and wrestling.[1,2] One study reported that among 88 university level football players (on one team), there were 12 burners over the course of a season, accounting for both game and practice exposure.[3] In 165 junior college football players (on three teams), there were 13 burners, and in 193 high school football players (on six teams) there were 15 burners.[3] Burner incidence increased with increasing level of play, and they were found to be sustained more frequently by defensive players.[3]

Symptoms of a burner generally consist of an intense burning sensation and/or sharp pain that originates in the neck and/or shoulder area, with paresthesia or dysesthesia radiating into the arm and hand.[1–6] The symptoms generally have a non-dermatomal pattern.[1,2,4] Decreased reflexes and sensation are also common.[3] Weakness in the shoulder musculature, including the biceps, deltoids, infraspinatus and supraspinatus, can be either an immediate sign or can be delayed in onset.[1–4] Symptoms from burners are usually not long-lasting, but can range from mild and transient (disappear within seconds) to severe and persistent.[2–6] Recurrences are common and persistent numbness and weakness can occur and are more likely for those who have experienced multiple burners over the course of a season or career.[2–6]

There are two main mechanisms generally believed to cause burners. The first involves a traction injury to the brachial plexus.[1–6] This is usually the result of lateral deviation of the neck away from the injured side with depression of the shoulder on the injured side.[1–7] The second mechanism for causing a burner involves compression of the cervical nerve roots at the intervertebral foramen.[1–5,7] Extension combined with any of rotation, lateral flexion, and/or compression of the cervical spine may elicit the symptoms.[1–7] A direct blow to Erb's point in the supraclavicular region can also cause burner symptoms.[1,3,4]

Due to the potential for burners to recur and for those with recurrent burners to have more persistent symptoms, primary and secondary prevention are important for the sports clinician, coach, and athlete. Measures for preventing burners can be divided into four categories: teaching of proper tackling and hitting technique, cervical and shoulder conditioning and strengthening, wearing properly fitted shoulder pads and helmets, and use of additional protective equipment such as cervical collars and rolls.[1–4,6–8]

Cervical collars and braces are intended to limit cervical hyperextension and lateral flexion, thus potentially limiting the two most common mechanisms of burner injury, while allowing for a normal active range of motion.[1,2,4–7] Neck rolls and "cowboy collars" are two commonly recommended and easily obtained forms of cervical orthoses.[1,4–7] This equipment needs to be properly installed onto the player's shoulder pads, preferably by an experienced equipment manager or sports practitioner, and then inspected before use.[2,6] Several authors recommend that any player who has experienced a burner should wear a cervical collar or brace when they return to action, if they do not already.[1,7] The objective of this review is to examine the literature regarding the use of cervical collars and braces in limiting lateral flexion and extension of the cervical spine, as well as in preventing burners and other cervical spinal injuries in athletes.

Methods

A literature search was conducted on MEDLINE (1970–2005), Cinahl (1982–2005), Alt Health Watch (1990–2005), AMED (1995–2005), and the Index to Chiropractic Literature (1985–2005) for trials relating to cervical collars/neck rolls and sports injury prevention (particularly for burners and other cervical spine injuries). Trials could use human subjects or inanimate models (such as a mannequin), and could be on-field or laboratory assessments of cervical collars.

The following search terms were employed: sports injury, neck, cervical, spine, collar or collars, neck roll, bracing, brace or braces, athletic equipment, burner or burners, brachial plexus. The following MeSH terms were also used in searches: athletic injuries, brachial plexus, cervical vertebrae, orthotic devices. Retrieved articles were also hand-searched for additional references.

Results

Only three trials were found relating to cervical collars or braces and sports brachial plexus injury or excessive cervical motion prevention.[4,5,9] Two were trials that took place in laboratory settings on human subjects and examined the ability of different collars to restrict cervical mo-

tion.[9] All of the subjects involved in these two trials were university level football players. The third identified study involved the on-field testing of a cervical orthosis on five United States Military Academy football players who suffered a previous burner injury and followed up with them after a season of wearing the orthosis.[9] The device was a total contact neck-shoulder-chest orthosis along with a neck roll.[9] Three of the players anecdotally reported that they had fewer burner episodes and less severe symptoms when an injury did occur.[9] No randomized controlled trials or further trials were identified that evaluated the use of cervical collars as either a primary or secondary preventive measure for preventing burners in on-field scenarios (game and/or practice situation), nor were there any articles that used an inanimate model (such as a mannequin).

Discussion

In 2003, Gorden et al. reported on a repeated-measures laboratory trial examining how well three different football collars reduced cervical hyperextension and lateral flexion in 15 healthy NCAA division one football players.[4] A cowboy collar (a molded collar with a padded vest), foam neck roll, and the A-Force neck collar (a molded collar held in place by straps that go under the armpits and fasten around the back) were tested on each player. Specifically the study looked at the amount of cervical spinal motion during ten different test conditions, as listed in tables 1 and 2.

Each test condition was repeated three times in both extension and lateral flexion, thus each player was tested 30 times in each direction, passively 15 times and actively 15 times. Cervical motion in hyperextension and later-

Table 1. Amount of cervical hyperextension allowed by different neck collars in different testing conditions.

Trial	Test Condition	Active or passive	Average Motion
Gorden et al.[4]	H	Active	82.90°
Gorden et al.[4]	H, SP	Active	77.97°
Gorden et al.[4]	H, SP, NR	Active	64.47°
Gorden et al.[4]	H, SP, CC	Active	56.59°
Gorden et al.[4]	H, SP, AFNC	Active	60.41°
Gorden et al.[4]	H	Passive	98.49°
Gorden et al.[4]	H, SP	Passive	93.53°
Gorden et al.[4]	H, SP, NR	Passive	84.71°
Gorden et al.[4]	H, SP, CC	Passive	71.47°
Gorden et al.[4]	H, SP, AFNC	Passive	76.14°
Hovis & Limbird[5]	H, SP	Passive	*3.52%
Hovis & Limbird[5]	H, SP, NR	Passive	*33.18%
Hovis & Limbird[5]	H, SP, CC	Passive	*32.36%
Hovis & Limbird[5]	H, SP, CB	Passive	*48.36%

* = Expressed in % reduction in angle of motion when compared to helmet alone
H = Helmet
SP = Shoulder pads
CC = Cowboy Collar
NR = Neck Roll
AFNC = A-Force Neck Collar
CB = Custom Brace

Table 2. Amount of cervical lateral bending allowed by different neck collars in different testing conditions.

Trial	Test Condition	Active or passive	Average Motion
Gorden et al.[4]	H	Active	49.44°
Gorden et al.[4]	H, SP	Active	41.37°
Gorden et al.[4]	H, SP, NR	Active	33.34°
Gorden et al.[4]	H, SP, CC	Active	39.05°
Gorden et al.[4]	H, SP, AFNC	Active	39.59°
Gorden et al.[4]	H	Passive	55.13°
Gorden et al.[4]	H, SP	Passive	49.72°
Gorden et al.[4]	H, SP, NR	Passive	47.10°
Gorden et al.[4]	H, SP, CC	Passive	48.03°
Gorden et al.[4]	H, SP, AFNC	Passive	47.13°
Hovis & Limbird[5]	H, SP	Passive	*17.34%
Hovis & Limbird[5]	H, SP, NR	Passive	*28.68%
Hovis & Limbird[5]	H, SP, CC	Passive	*18.92%
Hovis & Limbird[5]	H, SP, CB	Passive	*25.15%

* = Expressed in % reduction in angle of motion when compared to helmet alone
H = Helmet
SP = Shoulder pads
CC = Cowboy Collar
NR = Neck Roll
AFNC = A-Force Neck Collar
CB = Custom Brace

al flexion were assessed using video analysis with reflective markers applied to key locations on the player's equipment, with the camera four meters away from the subject. In the passive motion trials 30 pounds of overpressure was placed on the player's helmet. The amount of overpressure was measured with a hand-held dynamometer which contacted the helmet.

All three of the different collars significantly decreased hyperextension when compared to shoulder pads with helmet alone. Table 1 shows that the cowboy collar allowed the least hyperextension, followed by the A-Force Neck collar, and finally by the neck roll under both active and passive conditions. The cowboy collar was found to allow significantly less hyperextension than the neck roll. The authors concluded that all three of the cervical collars tested helped decrease cervical hyperextension when compared to shoulder pads and helmet alone, but also noted that between the three collars, an average of nearly 20 degrees of passive hyperextension was still possible.[4]

In lateral flexion the neck roll allowed the least active motion, followed by the cowboy collar and the A-Force Neck Collar, whose measurements were nearly identical, as can be seen in Table 2. Table 2 shows that there was little difference between the three collars in passive motion, with the neck roll providing the greatest reduction, followed by the A-Force Neck Collar and finally by the cowboy collar. The collars were generally unable to prevent passive lateral flexion more than helmet and shoulder pads alone. The authors commented that the ability of the neck roll to restrict active motion in lateral flexion more than the other collars may be undesirable. One would ideally like a collar to allow a player to actively move their head and neck as much as possible, but prevent excessive passive motion when they are hit.

The authors commented that the passive motions (overpressure) used in this trial were meant to simulate contact-induced head motion, as the force from the collision would be greater than the force the player's neck muscles produced.[4] The authors concluded that the Cowboy collar appeared to provide the greatest restriction in hyperextension and potentially the most effect in preventing burners, or other brachial plexus and neck injuries. The Cowboy collar also provides protection over Erb's point, which is potentially a source of burner symptoms when contacted directly.[4] The authors recommended modifications to all three braces to restrict excessive lateral flexion, as none adequately protect against it.[4]

In 1994, Hovis and Limbird reported on a laboratory trial where five college football players wore shoulder pads and helmet along with each of three different neck collars to evaluate the effect of the collars in limiting cervical hyperextension and lateral flexion.[5] The players applied stress to their cervical spines with a rope and pulley mechanism that attached to the helmet. The player pulled on a rope held in their hand that would lead to stress being applied to their neck and could thus control the amount of bending that occurred through this mechanism. Video analysis with reflective markers applied to key locations on the player's equipment was utilized to measure cervical spinal motion. Testing was done under five different equipment conditions as set out in Tables 1 and 2. Three pulls of the neck and head were performed for each test condition in both hyperextension and lateral flexion. Thus each player had 15 pulls in extension and 15 pulls in lateral flexion, leading to a total of 75 total hyperextension and 75 total lateral flexion motions between all five players.[5]

There was a significant difference in the limitation of hyperextension between the helmet and pads only trials and when any of the braces was added. As Table 1 illustrates, the custom-made cervical orthosis produced the greatest reduction in cervical hyperextension, followed by the neck roll, which was closely followed by the cowboy collar when compared to the helmet only trial.

However, there was no statistically significant reduction in lateral flexion when comparing the helmet and shoulder pads only trials with the trials where one of the braces was used. Table 2 shows that the neck roll produced the greatest reduction in cervical lateral bending angle when compared to the helmet alone scenario, followed by the custom brace, and finally by the cowboy collar.

Hovis and Limbird concluded that all of the braces reduced cervical extension to significantly greater extent than shoulder pads by themselves, but design modifications to the braces were needed to limit excessive lateral flexion.

In both of the identified laboratory trials, the addition of any of the rolls or collars to shoulder pads and helmet helped to significantly reduce cervical hyperextension. However, the addition of the rolls or collars generally did not have a significant effect on lateral flexion, with the exception of the neck roll in the active trial of the Gorden et al study. This is an important point for clinicians that should be communicated to players and coaches: while there may be some protection from excessive cervical hyperextension when wearing a neck collar or brace, there does not appear to be much or any protection against excessive lateral flexion and it is unproven whether wearing these collars actually prevents injury. As extreme contralateral cervical lateral bending with ipsilateral shoulder depression is one of the main mechanisms for causing a burner, a concern can be raised that these products may not provide adequate protection from burners. This can come as a warning, and that may be beneficial by simply raising awareness about these products and their potential weaknesses.

It should be noted that different types of foam rolls were used in the Hovis and Limbird study as opposed to the Gordon et al. study, and this could account for any difference in performance of the foam roll between the two studies (for example, it allowed the most hyperextension in the Gorden et al. study and allowed less hyperextension than the cowboy collar in the Hovis and Limbird study), as could the amount of force applied to the players' spines. Hovis and Limbird did not disclose the amount of force applied by the players with each pull, even though they did use a spring scale to measure for constant and consistent force application with each pull by each player.

Laboratory situations cannot perfectly simulate live action speed and contact force, particularly in sports that involve high speed collisions such as football, hockey, and lacrosse. In the two identified laboratory studies, the authors attempted to keep conditions as consistent as possible, and the authors also did not want to injure the players

involved (nor could they or should they from an ethical standpoint). In Gorden et al., they only used 30 pounds of force (133.5 N), and in Hovis and Limbird the players controlled the amount of force applied (and likely would not apply enough force to injure themselves). As Gatt et al. illustrated, when division 1-A college football players hit a blocking sled, the average force generated at the sled when measured with a force plate was 3013 ± 598 N (677.3 ± 134.4 pounds of force).[10] Thus it is possible that the results from these laboratory studies lack practicality, and the conclusions drawn from them should be taken with this in consideration. If possible, future laboratory studies could use more realistic amounts of force (possibly with a mannequin to avoid player injury). Future laboratory investigators may also want to evaluate the ability of braces and collars to restrict different ranges of motion (rotation in particular) or combinations of motion (such as lateral flexion, rotation, and extension) as would be seen in live action play.[4,5]

Randomized trials or controlled clinical trials are also needed, particularly ones that compare the ability of different neck collars, braces and interventions (such as player/coach education, cervical strengthening programs, etc.) to reduce burner frequency, as well as other cervical spinal injuries during game and practice scenarios in sports where these injuries are common and braces and collars are worn (football, hockey, and lacrosse). The study by Markey et al. found that their neck brace was felt to have decreased burner frequency and symptom severity in three out of five players evaluated.[9] However this was a very small sample size, only a small component of their entire study (which involved EMG and nerve root stimulation studies to identify damaged nerve tissues in players with burners), and the results were subjective.[9] From an ethical standpoint, on-field and in-play studies should be passable as players are already voluntarily exposing themselves to the risk of playing their given sport and the forces and collisions involved, and researchers would just be adding on interventions that would hopefully prevent injury to the players. Participation would naturally need to be voluntary as some players likely would not need or want to use collars or braces (such as quarterbacks and receivers in football, goalies in hockey or lacrosse, etc.).

This could be an opportunity for the manufacturers of these cervical collars and braces to take note of the potential deficiencies of their products. Through research and development they may be able to design cervical collars that can prevent excessive cervical lateral flexion, and further reduce the amount of hyperextension possible. As Cross and Serenelli point out, a new type of cervical orthosis known as a butterfly (or extension) restrictor has been developed in recent years by manufacturers in consultation with equipment managers.[6] These new orthoses are potentially modifiable as pads can be added to them that help limit lateral flexion, and are a promising development in burner prevention.[6] Unfortunately, to date no literature exists whereby their ability to limit motion has been scrutinized and compared with other braces/collars. Modifications could also potentially be made to the shoulder pads (increasing the thickness of the padding for example) or helmets (or a combination thereof) in order to produce the desired effects in limiting passive motion, while maintaining the ability of the player to move their head and neck when and where they need to during play. Designing equipment that prevents trauma to Erb's point is also desirable and recommended in helping to prevent burners.

As mentioned previously, there are numerous ways to potentially prevent burners and other cervical sports injuries, besides the use of cervical collars and braces, which should be emphasized to coaches, players, and sports medicine personnel.[1–4,6–8] Proper tackling and hitting technique for players, particularly young players, is important and can help prevent injury onset.[1–3,6] The neck muscles function as a shock absorber for the cervical spine in contact sports, and thus neck and trapezius strengthening should be performed year-round by the athlete.[1,3,6,7] Equipment for football, hockey, and lacrosse players should fit properly and should be fit for each player individually.[2,6] Shoulder pads should not sit low on players as this allows for more lateral flexion of the neck.[3,6] Players with previous burners may consider additional padding underneath their shoulder pads to lift the pads off their shoulders and decrease the amount of lateral flexion possible.[2]

Proper management of these injuries can also help prevent recurrence. Any player that has suffered a burner should not return to play until they have obtained medical/chiropractic clearance. Resumption of contact should not be allowed until the player is asymptomatic, has full strength and full and pain-free active and passive ranges

of motion, an unremarkable neurological examination, negative Spurling's test, and negative axial compression tests.[1–3,7,8]

Conclusion

In sports with numerous high-speed collisions such as football, lacrosse, and hockey, it is prudent for players, coaches, and sports clinicians (including chiropractors) to do all that they can to prevent cervical spinal injuries such as burners. All attempts should be made to ensure player safety through proper conditioning and strengthening, teaching and use of proper hitting and tackling techniques, and the appropriate use and fitting of protective equipment. Wearing a neck collar or brace could also be added to the list of potentially useful preventive measures. Unfortunately to date only one very small study with empirical data exists that evaluates the ability of a cervical orthosis to prevent burners or other cervical spinal injuries. Laboratory investigations have shown that collars and braces can help to restrict cervical hyperextension, but do not appear to aid greatly in preventing excessive lateral bending. Further innovations or design modifications to these braces and collars are warranted to address this situation, as are randomized controlled trials to assess whether such interventions actually do prevent injury.

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