Cervical Spine Alignment in the Youth Football Athlete: Recommendations for Emergency Transportation

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Cervical Spine Alignment in the Youth Football Athlete

Recommendations for Emergency Transportation

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Background: Substantial literature exists regarding recommendations for the on-field treatment and subsequent transportation of adult collision-sport athletes with a suspected injury to the cervical spine.

Purpose: To develop an evidence-based recommendation for transportation of suspected spine-injured youth football players.

Study Design: Descriptive laboratory study.

Methods: Three lateral radiographs were obtained in supine to include the occiput to the cervical thoracic junction from 31 youth football players (8-14 years). Each child was imaged while wearing helmet and shoulder pads, without equipment, and with shoulder pads only. Two independent observers measured cervical spine angulation as Cobb angle from C1 to C7 and subaxial angulation from C2 to C7. We calculated intraclass correlation coefficients for intraobserver reliability analysis and compared Cobb and C2 to C7 angles between equipment conditions with *t* tests.

Results: Interobserver analysis showed excellent reliability among measurements. Cobb and subaxial angle measurements indicated significantly greater cervical lordosis while children wore shoulder pads only, compared with the other 2 conditions (no equipment and helmet and shoulder pads) ($P \leq .001$). There was no statistically significant difference in either Cobb or C2-C7 angles between fully equipped (helmet + shoulder pads) and no-equipment conditions ($P > .05$).

Conclusions: Equipment removal for the youth football athlete with suspected cervical spine injury should abide by the "all or none" policy that has been widely accepted for adult athletes. Helmet and shoulder pads should be left in place during emergency transport of the suspected spine-injured youth athlete.

Clinical Relevance: Despite differences in head to torso size ratios between youth and adult players, helmet removal alone is not recommended for either during emergency transportation.

Keywords: youth football; cervical spine; emergency transportation; injury

Cervical spine injuries in contact and collision sports are rare but potentially catastrophic events. These sports, which include football, ice hockey, and lacrosse, have become increasingly popular among youth. Participation in tackle football by children aged 7 to 17 years increased 44.6% between 1997 and 2006.[10] This increase in participation along with year-round participation has increased the total number of exposures to sports-related injury. This increased potential for injury to the cervical spine among participants in contact and collision sports highlights the importance of specific on-field management recommendations. The National Athletic Trainers Association has outlined on-field management guidelines for the mature athlete with a suspected cervical spine injury.[8] Helmet and shoulder pads should be left in place for immobilization and transport on a spine board to minimize motion and angulation of the cervical spine. The face mask is detached from the helmet to provide airway access. Removal of the equipment can then be performed in a controlled setting with appropriate monitoring and trained personnel available, decreasing the risk of further injury to the athlete.[4,8,13]

The current standard of care for on-field management of cervical spine injuries is based on studies of adult male subjects.[9,11,14] Herzenberg et al[7] demonstrated that the developing child has an increased head to torso size ratio that results in relative kyphosis when the child lies supine,

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and they recommended that a spine board with a head cutout be used for the young patient to prevent cervical kyphosis. Those investigators also showed that the sizes of the head and torso increase at different rates and along different growth curves, allowing the potential for smaller, residual skeletal disproportion until maturity is reached. Likewise, Curran et al[3] found that the potential for sagittal cervical spinal malalignment in the immobilized pediatric patient persists past the age of 6 to 8 years. Although recommendations for the immobilization of the young pediatric trauma patient and the adult football player with a suspected cervical spine injury are well established, it remains unstudied whether the residual difference in head to torso ratio in the older skeletally immature patient will affect spinal alignment when the variable of tackle football equipment is introduced.

To our knowledge, the relationships among these residual anatomical differences, sporting equipment, and spinal angulation have not been studied in 8- to 14-year-old football players. The results from the pediatric spine literature and the adult football literature cannot be projected onto this unstudied pediatric population. The purpose of this study was to evaluate cervical spine alignment in youth football players with equipment to determine whether the current adult standard of care held true in this age group. We hypothesized that the residual increased head size of the older pediatric athlete relative to the torso would result in relative kyphosis of the cervical spine with the helmet and shoulder pad condition and that removing the helmet would result in a spinal alignment closer to that of the no-equipment condition.

METHODS

Thirty-one male athletes aged 8 to 14 years old (133.6 ± 18.8 months; 10.7 ± 1.7 years; 150.2 ± 14.0 cm; 41.3 ± 9.9 kg) were recruited from a local youth football league to participate in this study. There were 8 boys aged 8 to 9 years, 12 boys aged 10 to 11 years, and 11 boys aged 13 to 14 years. All subjects assented to the study and were accompanied by a parent, who also provided consent to participate. Both parent and child understood the methods and risks associated with this study and signed the appropriate form in accordance with our university's institutional review board approval. Exclusion criteria included previous cervical spine injury.

Three lateral cervical spine radiographs were obtained to include the occiput to the cervicothoracic junction for each subject. Each child was imaged supine with no equipment, with shoulder pads only, and with helmet and shoulder pads (Figure 1). Measurements were then made using readily identifiable landmarks for each image set with 2 methods: cervical spine angulation measured as a Cobb angle from C1 to C7 and subaxial angulation from C2 to C7 as defined by Gore et al.[6] All measurements were performed separately by a sports medicine fellow and a senior orthopaedic resident proficient in these measurements. Measurements were then compared to determine the overall cervical angulation for each condition and the change from the no-equipment condition. Data from the radiographic evaluation were compared with the subject's height, weight, and age to look for relationships between these variables.

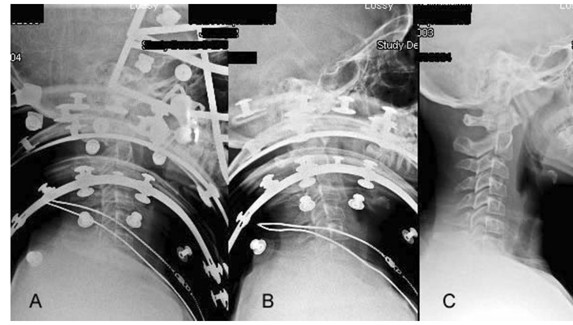

Figure 1. Sample supine lateral radiographs taken of a 12-year-old child wearing helmet and shoulder pads (A), shoulder pads only (B), and no equipment (C).

TABLE 1
Cobb and Subaxial Angle Measurements (Mean ± SD)

	Cobb Angle	Subaxial Angle
Helmet + shoulder pads	24.2 ± 13.6[a]	10.9 ± 11.1[a]
Shoulder pads only	34.6 ± 13.9[b]	19.1 ± 12.0[b]
No equipment	22.9 ± 14.9	8.2 ± 14.0
Change with helmet and shoulder pads compared with angle with no equipment	1.4 ± 16.7[c]	2.7 ± 14.1[c]
Change with shoulder pads only compared with angle with no equipment	11.7 ± 14.9	10.9 ± 13.5

[a]Not different from no-equipment condition (P = .65, Cobb; P = .30, subaxial).

[b]Significantly greater cervical lordosis compared with no equipment and helmet + shoulder pads (P < .001).

[c]Significantly less change in cervical angle when subjects wore helmet + shoulder pads compared with the change when subjects wore shoulder pads only (P < .001).

We calculated intraclass correlation coefficients (ICC[2,1]) for interobserver reliability analysis between the 2 measurers. We also performed a 1 × 3 repeated-measures analysis of variance to compare Cobb and C2-C7 angles between each condition. Dependent samples t tests were used post hoc to determine the exact differences between each equipment condition. Pearson r correlation coefficients were used to determine whether there was an association between age, height, and weight on cervical alignment. We decided a priori that differences would be considered statistically significant if the P value was ≤.05.

RESULTS

Interobserver analysis showed excellent reliability among measurements (ICC[2,1] range: 0.87-0.95). There was a significant difference among Cobb ($F_{2,60}$ = 11.61, P <.001) and subaxial ($F_{2,60}$ = 11.01, P <.001) measurements between the different equipment conditions (Table 1). Cobb and subaxial angle measurements indicated significantly greater cervical lordosis while children wore shoulder pads only compared

TABLE 2
Descriptive Demographics by Age Group Including the Average Change in Cervical Spine Angle

		Cobb Angle		Subaxial Angle	
	n	≥3° Change, n (%)[a]	Angle Change[b]	≥3° Change, n (%)[a]	Angle Change[b]
8-9 y	8	6 (75)	11.3 ± 20.4	6 (75)	11.4 ± 12.0
10-11 y	12	8 (67)	8.9 ± 8.3	6 (50)	5.3 ± 11.6
12-14 y	11	9 (82)	8.6 ± 9.8	8 (73)	9.2 ± 16.7
Overall (8-14 y)	31	23 (74)	10.4 ± 12.8	20/31 (65)	8.3 ± 13.0

[a]The number of children who experienced ≥3° increases in cervical lordosis when only the helmet was removed, compared with wearing full equipment.
[b]Average change in cervical spine angle with helmet off compared with full equipment.

with the no-equipment and helmet and shoulder pads conditions ($P \leq .001$). When the helmet was removed in isolation from subjects wearing both helmet and shoulder pads, 74.2% of the children (23/31) in the current study experienced greater than 3° increases in cervical spine lordosis measured with the Cobb technique; 64.5% of the children (20/31) experienced greater than 3° increases in lordosis measured with the subaxial technique.

There was no statistically significant difference in Cobb or C2-C7 angles between fully equipped (helmet + shoulder pads) and no-equipment conditions ($P > .05$). Correlation analysis indicated that age, height, and weight were not related to cervical spine angulation under any of the equipment conditions or the change in cervical spine angulation when compared with the no-equipment condition. However, we have presented data separately by age group in Table 2.

DISCUSSION

Pediatric cervical spine injury is an important although relatively uncommon entity in the trauma setting. However, of those children injured, participants in sport represent an important subgroup. Using data from the National Pediatric Trauma Registry, Patel et al[12] found that 1.5% of all pediatric trauma patients sustained cervical spine injury. Twenty percent of cervical spine injuries in patients older than 8 years were secondary to sports participation. This injury mechanism was behind only motor vehicle collisions and falls in frequency. Similarly, Brown et al[2] found that 27% of pediatric cervical spine injuries were secondary to sports participation, with football players representing 29% of this group. These findings highlight the need for specific guidelines for the initial management of potential cervical spine injury in the pediatric sports population.

Damage to the cervical spine is a potentially catastrophic event in collision sports. On-field treatment of athletes with suspected neck injuries is of paramount importance. Boden et al[1] recently reviewed cervical spine injuries in high school and college football players over a 13-year period using the National Center for Catastrophic Sports Injury Research database. This study found that 15 cervical spine injuries occur per year with an incidence of 1.1 and 4.72 injuries per 100 000 high school and college football players per year, respectively. During the period studied, the incidence of quadriplegia was 1 per 192 000 participants. Although the increased size and speed of older players put them at higher risk,[1] the increased participation of younger athletes in collision sports such as football, ice hockey, and lacrosse has increased the number of exposures for these injuries.

Several studies have evaluated the effect of athletic equipment on the position of the cervical spine.[9,11,14] Swenson et al[14] evaluated 10 healthy male subjects using a standard football helmet and shoulder pads and showed an increase in cervical spine lordosis when the helmet was removed and shoulder pads left in place. No significant difference in cervical lordosis was seen between the no-equipment and fully equipped conditions. Similar findings were demonstrated by Laprade et al[9] using hockey equipment in 10 subjects. Cadaver models simulating instability of the cervical spine have also demonstrated that a football helmet and shoulder pads align the cervical spine more effectively than removal of one or the other.[5,11] Additionally, in a cadaver model with instability at C1-C2 and at C5-C6, Donaldson et al[4] showed that equipment removal results in increased motion at these segments, and the investigators recommended doing so only in a controlled situation. These findings support the guidelines established by the National Athletic Trainers Association to leave protective equipment in place during on-field management and transportation if an athlete is suspected to have a cervical spine injury.[11]

Although substantial literature supports the current recommendations for the initial management and transportation of mature athletes with a suspected cervical spine injury, little information exists for the pediatric participant. The current management of younger players is based on the study of skeletally mature subjects. Different portions of the human skeleton reach adult sizes at variable times during development. This differential growth results in changing proportions as a child matures. Younger children have a large head to torso size ratio that decreases as the child matures.[7] This larger ratio results in the neck resting in relative kyphosis when the child is immobilized on a standard spine backboard. Consequently, children aged 6 years old and younger should be transported on a modified backboard with a head cutout allowing the cervical spine to rest in more neutral alignment.[7] Although recommendations for spinal immobilization of trauma patients change between the ages of 6 and 8 years, smaller anatomical differences persist after this age with gradual normalization of proportions as the child's skeleton matures.[7]

While demonstrating that the young child has an increased head to torso size ratio that results in relative cervical kyphosis when the child lies supine, Herzenburg et al[7] also showed that the sizes of the head and torso increase at different rates and along different growth curves, allowing the potential for smaller, residual skeletal disproportions until maturity is reached. In the anthropometric portion of the study, the authors created head circumference and thoracic circumference growth curves using established data in the literature. They found that head circumference increases along a logarithmic curve, whereas thoracic growth demonstrates linear characteristics. Furthermore, the human head reaches 50% of its adult circumference by age 18 months, whereas thoracic circumference does not reach this milestone until 8 years of age. The growth curves produced in this study demonstrate that even though head circumference increases at a more linear rate after age 8 years, the rate of growth is substantially slower than that of the thorax during the remainder of skeletal maturation. Although the greatest proportional differences are seen in the younger child, a difference in growth rate, even when both are increasing linearly, can result in residual proportional differences in children of different skeletal ages. Additionally, Curran et al[3] found that the potential for sagittal cervical spine malalignment persists past age 6 to 8 years. Evaluating several methods of cervical immobilization, they showed that although less common, the potential remains for immobilization in flexion in the older pediatric trauma patient and that alignment of the immobilized cervical spine is not dependent on only the age of the child.

Immobilization recommendations for children younger than age 6 to 8 years are well established and are different than recommendations for older children and adults. Also well established are on-field management recommendations for mature athletes with suspected cervical spine injury. However, although recommendations exist for the pediatric trauma patient, we do not believe that it can be assumed from the pediatric spine literature or from the adult football immobilization studies that once the variables of helmets and shoulder pads are introduced to the maturing pediatric patient, results can be extrapolated from these 2 sources to define on-field recommendations for an unstudied group. The possibility remains that residual skeletal disproportion, although not large enough to require changes in immobilization techniques in the trauma setting, could be accentuated by the addition of football equipment and justifies the study of the relationship between spinal alignment and football equipment in this age group.

In this study, we evaluated 31 youth league football players between the ages of 8 and 14 years with no equipment, shoulder pads only, and helmet and shoulder pads. Lateral radiographs demonstrated that although variability existed in the cervical position without equipment, removal of the helmet resulted in statistically significant greater cervical lordosis. Additionally, the spinal alignment with helmet and shoulder pads did not differ significantly from the no-equipment condition. These findings are in line with the findings of previous studies in adult athletes.[5,9,11,14]

We anticipated that proportionally larger heads in children could result in flexion of the cervical spine with helmet and shoulder pads in place, resulting in kyphosis and necessitating helmet removal for safe transport. This was not the case in children of any age in our study, rejecting our hypothesis. The equipment negated any residual effects of the patient's skeletal proportions on sagittal spinal alignment, resulting in an interaction between the subject and equipment similar to the adult condition. Furthermore, no associations were found between the subjects' height, weight, or age and the degree of cervical angulation seen.

Weaknesses of this study include the use of healthy subjects. Perhaps, in the case of spinal instability, findings in this age group could be different, although such an investigation would be extremely dangerous and impractical. In addition, the age range of the subjects necessarily includes children of varying skeletal maturity. We believe that inclusion of these subjects represents the situation seen in youth football leagues and was required to evaluate for potentially different results across a representative age range. Finally, aside from height and weight, no anthropometric data were collected. The purpose of this study was to identify an association between readily available variables and spinal alignment that might guide emergency personnel during immobilization and transportation of young athletes.

Although definite anatomic differences exist between the skeletally mature and immature athlete, this study supports the use of current adult recommendations for spinal immobilization in athletes 8 years of age and older. Specifically, helmet and shoulder pads should be left in place in the young football player with a suspected spinal injury. These results pertain directly to football equipment only. It is unclear whether the information can be extrapolated to other collision sports such as ice hockey and lacrosse.

CONCLUSION

Current recommendations for the initial management and transportation of the pediatric athlete with a suspected cervical spine injury are based on the study of adult male subjects. Despite the differences in the skeletal proportions of young athletes, our findings indicate that if a cervical spine injury is suspected, the participant should be transported with helmet and shoulder pads in place. This recommendation is consistent with the "all or none" guidelines for the injured adult athlete.

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