Football Equipment Designs - Effects on Acute Airway and Cardiovascular Care in Medical Emergencies

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Agenda

- The Set-up
  - Background and Context
  - Clinical Recommendations
- The Study
  - Methods and Results
  - Technique Considerations
- The Implications
  - Clinical Interpretation
  - Thoughts for Discussion

The Set-up

Why do we strive to minimize motion?

Carlson GD et. al. (JBJS 2003)

Magnetic resonance images of the spinal cords of dogs with T13 injury after 30 minutes (A) or 180 minutes (B) of spinal cord compression. The arrows indicate areas of preserved white matter.
Carlson GD et al. (JBJS 2003)

- "Longer duration of compression is associated with increased pathological changes and decreases in neurologic recovery"

- "Damage to the spinal cord depends strongly on the duration of displacement and timing of treatment"

Deviations from neutral alignment can decrease the diameter of the spinal canal and the space available for the spinal cord

Ching RP et al. (Spine, 1997) investigated the effect of post-injury position of the cervical spine on spinal canal occlusion

- Burst fractures created in cadaver cervical spines
- Each specimen moved into:
  - Flexion / Extension
  - R/L Lateral Flexion
  - 4 intermediate positions (45°)
  - L/R Rotation
  - Traction
  - Compression
- Compared with the neutral position; compression, extension, and extension combined with lateral flexion all increased canal occlusion.

Patient Outcomes

Kang JD et al. (JBJS 1994) reviewed medical records of 288 patients (age ~ 36 yrs) w closed cervical spine fractures or dislocations between 1966-1992.

- 83 no neurologic def, 30 nerve root, 92 incomplete, 83 complete
- Determined SAC at injured levels:
  - 10.5 mm for complete injury
  - 16.7 mm for no neurologic injury
- Identified an association between the space available for the cord at the level of injury and the severity of neurologic deficit.

Why do we strive to minimize motion?

"We minimize motion in an effort to avoid positioning away from neutral alignment!"

If the head/neck is OUT of neutral alignment... in a suspected cervical spine injury, it is ok to move the head/neck ... back to neutral.
“Do no Further Harm....”

Does not necessarily mean...

.........“Do Nothing”

Repositioning the Cervical Spine

Three general contraindications exist to moving the cervical spine to neutral:
1. the movement causes or increases pain, neurologic symptoms, or muscle spasm compromising the airway,
2. resistance to movement is encountered, or
3. the patient expresses apprehension.

Clinical Recommendation

Always ensure the cervical spine is in, and remains, in neutral alignment

ANNUAL SURVEY OF CATASTROPHIC FOOTBALL INJURIES 1977 – 2011

• “There has been a reduction of permanent cervical cord injuries when compared to data from the early 1970’s.

• For the past ten years, 2002 - 2011, there has been an average of 9.4 cervical cord injuries with incomplete neurological recovery, and 8.2 cerebral injuries with incomplete recovery in football.
• The prior ten years averaged 7.7 cervical cord injuries with incomplete recovery and 5.0 cerebral injuries with incomplete recovery."
What is a Major Part of the Problem?

What is a Major Part of the Problem?

It is discouraging to say the least that countermeasures (protective equipment) designed to lower the burden of injuries in sport and recreational activities do not warrant the same scientific scrutiny as in almost any other field of health research...

...the possibility exists that the countermeasure may have other negative unintended consequences...including shifting the distribution of injury, a change in behavior of participants resulting from a false sense of security, to reduced participation...due to public discontent

The Rise of Catastrophic Injury?

The Rise of Catastrophic Injury?

| 1969-1972 |

| Head impacts sustained in helmets-only (22.47 ± 1.81 g) and full-contact practices (22.65 ± 1.80 g) were significantly higher than those sustained in games or scrimmages (21.12 ± 1.73 g).

| Head impacts sustained in games or scrimmages (21.12 ± 1.73 g) were significantly higher than those sustained in full-contact practices (22.65 ± 1.80 g) and in the 2005 - 2010 period (20.89 ± 1.65 g).

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| Head impacts sustained in the 2005 - 2010 period (20.89 ± 1.65 g) were significantly lower than those sustained in full-contact practices (22.65 ± 1.80 g) and in games or scrimmages (21.12 ± 1.73 g).
TABLE 3. Frequency (number) of head impacts sustained by impact location in 2005 and 2006 football seasons

<table>
<thead>
<tr>
<th>Location of head impact</th>
<th>Frequency of recorded impacts</th>
<th>Mean (sd) linear impacts acceleration (g) of recorded head</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top</td>
<td>10,220 (18.81%)</td>
<td>28.23 (1.63)</td>
</tr>
<tr>
<td>Front</td>
<td>20,450 (35.86%)</td>
<td>28.08 (1.63)</td>
</tr>
<tr>
<td>Back</td>
<td>17,617 (30.89%)</td>
<td>27.78 (1.57)</td>
</tr>
<tr>
<td>Left</td>
<td>3926 (6.88%)</td>
<td>19.19 (1.47)</td>
</tr>
<tr>
<td>Right</td>
<td>4303 (7.55%)</td>
<td>18.05 (1.47)</td>
</tr>
<tr>
<td>Total</td>
<td>57,024</td>
<td>22.23 (1.79)</td>
</tr>
</tbody>
</table>

**Clinical Recommendation**

“Athletic training encompasses the prevention, diagnosis, and intervention of emergency, acute, and chronic medical conditions involving impairment, functional limitations, and disabilities.”

**What are YOU doing to prevent head/neck injury?**

**KEY POINTS!**

- Contact, Collision, and “Big Hits” are a part of the game
- Head impacts are cumulative and can result in detrimental, catastrophic outcomes
- We must continue our efforts to prevent catastrophic head and neck injuries and to strive for excellence in treating them…

**The Study**

“Adapted with permission Clinical Recommendation”
The primary acute treatment goals in equipment laden athletes are to ensure that the cervical spine is immobilized in neutral and vital life functions are accessible. Removal of helmet and shoulder pads in any equipment intensive sport should be deferred until the athlete has been transported to an emergency medical facility, except under 3 circumstances:

1. The helmet is not properly fitted to prevent movement of the head independent of the helmet,
2. The equipment prevents neutral alignment of the cervical spine, or
3. The equipment prevents airway or chest access.

Face Mask Removal is Safer than Helmet Removal... Right?

No research comparing motion created by facemask and helmet removal have been reported.

Recent changes in football helmet, facemask, and shoulder pad designs have implemented quick-release systems aimed at reducing removal time.

Full QR Helmet Options
Objective

- To determine the safest emergency intervention to allow for successful airway and chest access in recently modified styles of helmets and shoulder pads.

Hypotheses

1. There will be significantly less head movement and time to task completion during facemask removal compared to helmet removal
2. There will be significantly less head movement and time to task completion during shoulder pad removal using a quick release shoulder pad design compared to a traditional shoulder pad design

Study Design

- Quasi-experimental design comparing airway access and chest access techniques
- A controlled laboratory setting

Participants

- Forty athletic trainers (ATs) free of physical pathology preventing them from completing the required tasks were recruited through email distribution from the population of certified athletic trainers (ATs) in the New England region

<table>
<thead>
<tr>
<th>Males</th>
<th>Females</th>
<th>Age</th>
<th>Mass</th>
<th>Height</th>
<th>Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>19</td>
<td>33.7 ± 11.2 yrs</td>
<td>80.7 ± 17.1 kg</td>
<td>173.1 ± 9.2 cm</td>
<td>10.6 ± 10.4 yrs</td>
</tr>
</tbody>
</table>

- Participants reported in pairs
- All participants were informed of the study’s purpose
- A general overview of the study was provided
- Required to sign an informed consent form approved by the university’s IRB.
- Participants completed a general health history questionnaire to determine their inclusion eligibility.
- Incentive included a $30 gift-card and up to 2 CEUs.
- Participants were then randomly assigned to serve as Rescuer 1 or 2
Methods

- Participants observed specific demonstrations of facemask, helmet, and shoulder pad removal techniques used to gain access to the airway and the chest
- Participants were permitted to practice the techniques until they reported feeling comfortable with the expectations
- A 5-minute rest period was initiated prior to data collection
- 16 data-collection helmets were organized in the random order assigned a-priori

We had 4 conditions:

- Schutt ION4D FMR
- Riddell 360 FMR
- Schutt ION4D and Traditional shoulder pads
- Riddell 360 and RipKord™ shoulder pads

16 trials per data collection session

- 2 participants in each session and
- Required each participant to perform each condition 2 times

Airway Access Conditions

- Participants were trained in removal of facemasks attached to Schutt ION4D and Riddell 360 helmets
- Participants were also trained in manual helmet removal for the same types of helmets

Chest Access Conditions

- Participants were trained to remove both a traditional style of Riddell shoulder pads and the same style of shoulder pads, but which incorporated the new Riddell RipKord™ quick-release system
- The helmet removal conditions and shoulder pad removal conditions were performed within the same trials since the removal of one generally dictates removal of the other

Instrumentation and Equipment

- An 8-camera, high speed 3-D motion capture and analysis system (Motion Analysis Corp) recorded movement of the helmet and torso during the data collection trials
  - A model was outfitted with a 6-point, 2-segment marker set in order to record and analyze head movement during the removal trials

- A digital stopwatch was used to time each trial
  - The stop-watch was used to record transition (split) times which were later integrated into the motion analysis software to delineate motion that occurred relative to the specific task (helmet removal or shoulder pad removal)

- Subjects reported difficulty associated with each trial using a Modified BorgCR10 scale
Instrumentation and Equipment

- Ten new Schutt Ion 4D and 10 new Riddell 360 helmets (8 for data collection and 2 for training) and 2 new sets each of Riddell Power and Riddell Power with RipKord™ shoulder pads were acquired for the study.
- Two live, healthy volunteers (models) wearing appropriately-fitted football helmets and shoulder pads simulated the injured football player throughout the study.

Technique Considerations

Riddell Quick Release System

Remove Cheek Pads

- Removal of Cheek Pads from Traditional Helmets is not easy.

Cheek Pad Removal

- Schutt ION4D
- Riddell Revolution, Speed, 360
Deflates Bladders

Which Bladders are Accessible?

Chin Strap Removal

Chin Strap Removal

Head Stabilization
Open Shoulder Pads

Data Processing and Analysis

Data Processing and Analysis

- 3-D data were tracked and smoothed using a recursive, fourth-order, low-pass Butterworth filter (10 Hz).
- Digitized raw x-, y-, and z-coordinates for the dynamic and static trials were exported from EVaRT into the Kintrak 6.02.
- Joint centers were calculated based on a static trial for the models using an embedded right-hand Cartesian segment coordinate system.
- The range of motion excursion variable was created for each plane and analyzed for each trial.

Data Processing and Analysis

- Previously recorded transition times were manually inserted into the respective trials and the range of motion was calculated between each transition period which yielded 3 motion values for each trial.
- Motion data were exported and integrated into a master spreadsheet containing all analysis variables and prepared for export to a statistical analysis program.
Data Processing and Analysis

- Independent variables
  - facemask removal technique (Schutt Ion4D and Riddell 360)
  - helmet removal style (Schutt Ion4D and Riddell 360)
  - shoulder pad removal technique (Traditional and RipKord™)

- Dependent variables:
  - time,
  - motion, and
  - rating of difficulty

Analysis

- 2x2 (helmet type x airway access technique) within-subjects repeated measures ANOVA for each dependent variable.
- Paired-samples t-tests were also employed to evaluate differences between our shoulder pad designs for each dependent variable.
- SPSS 19 (IBM Corp.; Armonk, NY),
  - alpha level = 0.05

RESULTS

<table>
<thead>
<tr>
<th>Variable</th>
<th>RS360-FMR</th>
<th>ION-FMR</th>
<th>RS360-HR</th>
<th>ION-HR</th>
<th>Interaction</th>
<th>Helmet Type(^a)</th>
<th>Airway Technique(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal ROM</td>
<td>6.80 (1.70)</td>
<td>7.27 (2.94)</td>
<td>7.58 (2.34)</td>
<td>7.27 (2.94)</td>
<td>0.59</td>
<td>0.45</td>
<td>0.56</td>
</tr>
<tr>
<td>Frontal ROM</td>
<td>4.82 (1.19)</td>
<td>4.68 (1.34)</td>
<td>4.68 (1.41)</td>
<td>4.82 (1.19)</td>
<td>1.46</td>
<td>0.24</td>
<td>0.45</td>
</tr>
<tr>
<td>Transverse ROM</td>
<td>5.72 (1.15)</td>
<td>5.73 (1.57)</td>
<td>5.72 (1.15)</td>
<td>5.73 (1.57)</td>
<td>0.06</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Time, sec</td>
<td>36.12 (7.86)</td>
<td>26.05 (6.79)</td>
<td>20.45 (3.57)</td>
<td>20.45 (6.29)</td>
<td>3.12 (0.09)</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>RPE</td>
<td>2.08 (0.88)</td>
<td>2.18 (0.87)</td>
<td>2.14 (0.87)</td>
<td>2.13 (0.87)</td>
<td>0.54</td>
<td>0.04</td>
<td>0.45</td>
</tr>
</tbody>
</table>

\(^a\)Helmet type main effect compared RS360 to ION, across both airway access techniques (collapsed means for FMR and HR)

\(^b\)Airway access technique main effect compared FMR to HR, across both helmet types (collapsed means for RS360 and ION)

\(^c\)Denotes statistically significant findings
Results

- Athletic trainers required significantly less time to remove the RipKordTM shoulder pads (21.96 ± 3.08 s) than traditional shoulder pads (29.22 ± 4.45 s) (t19 = 9.80; P<0.001).
- There were no significant differences in sagittal (t19 = 1.63; P=0.119), frontal (t19 = 0.80; P=0.435), or transverse (t19 = 1.10; P=0.285) cervical spine motion resulting from shoulder pad removal between the two designs.

Chest Access

<table>
<thead>
<tr>
<th>Variable</th>
<th>Traditional</th>
<th>RipKord</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal ROM, °</td>
<td>14.10 (2.90)</td>
<td>12.84 (2.17)</td>
<td>1.63</td>
<td>0.119</td>
</tr>
<tr>
<td>Frontal ROM, °</td>
<td>6.84 (1.55)</td>
<td>6.49 (1.21)</td>
<td>0.80</td>
<td>0.435</td>
</tr>
<tr>
<td>Transverse ROM, °</td>
<td>6.92 (1.22)</td>
<td>6.52 (1.24)</td>
<td>1.10</td>
<td>0.285</td>
</tr>
<tr>
<td>Time, sec</td>
<td>29.22 (4.45)</td>
<td>21.96 (3.08)</td>
<td>9.80</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>RPE</td>
<td>2.13 (0.87)</td>
<td>2.28 (0.70)</td>
<td>0.80</td>
<td>0.435</td>
</tr>
</tbody>
</table>

The Implications

Clinical Interpretation and a Discussion

- As hypothesized, FMR induced less motion than HR when accessing the airway, validating current clinical recommendations. PHEW!!
- Quick-release loop straps allow FMR to be completed in clinically acceptable times with less motion in all planes.
- Future research should continue to examine the effects of helmet designs on emergency airway access.
Major Findings

- Our data suggest that the new RipKord™ design allows ATs to remove shoulder pads more quickly, without compromising cervical spine motion or introducing additional difficulty to the task.
- These results can only be generalized to the flat torso technique of shoulder pad removal at this time.
- Future research should examine the efficacy of such shoulder pad designs in allowing for effective access to the chest as would be needed in cardiovascular emergencies.
- Incorporating these equipment advances to other sports should be considered.

Challenges with Traditional Shoulder Pads

Levitation Technique
Traditional Shoulder Pads

Flexed Torso Technique
Traditional Shoulder Pads

Current Recommendations
What if the Equipment has to come off Here??

No matter what, at some point the equipment has to come off, in order to effectively diagnosis and treat the athlete.

Do we WANT the equipment to come off here??

If helmet removal becomes necessary, recommendations call for simultaneous shoulder pad removal (all-or-none principle)

Tierney et al., Gastel et al, Donahue et al, Laprade, Metz, Sherbondy, Palumbo et al

Historical Context

Results

- Cervical lordosis was similar (P>0.05) when comparing the BL (10.1±8.7) to the T0 (9.5±6.9, P>0.05) and to the T20 (6.5±6.8)
- Measurements taken at NT (14.4±8.1) demonstrated a significant increase in cervical lordosis compared to T0 (P=0.011) and T20 (P<0.001)

C2-C6 Cobb angle
Is it Better to Just Remove the Shoulder Pads on the Field?

The primary acute treatment goals in equipment laden athletes are to ensure that the cervical spine is immobilized in neutral and vital life functions are accessible. Removal of helmet and shoulder pads in any equipment intensive sport should be deferred until the athlete has been transported to an emergency medical facility, except under 3 circumstances:

1. the helmet is not properly fitted to prevent movement of the head independent of the helmet,
2. the equipment prevents neutral alignment of the cervical spine, or
3. the equipment prevents airway or chest access.

Evidence Category: C

Pre-Hospital Equipment Removal

1. Full medical access to airway and chest
2. Immediate use of AED
3. Improved ability to manage shock (control body temperature)
4. Improved ability to utilize cervical collar
5. Ability to immediately perform an x-ray
6. Ability to immediately perform an MRI

Thank You!