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Emergent Access to the Airway and Chest in American Football Players

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Context: American football has the highest rate of fatalities and catastrophic injuries of any US sport. The equipment designed to protect athletes from these catastrophic events challenges the ability of medical personnel to obtain neutral spine alignment and immobilization during airway and chest access for emergency life-support delivery.

Objective: To compare motion, time, and difficulty during removal of American football helmets, face masks, and shoulder pads.

Design: Quasi-experimental, crossover study.

Setting: Controlled laboratory.

Patients or Other Participants: We recruited 40 athletic trainers (21 men, 19 women; age = 33.7 ± 11.2 years, height = 173.1 ± 9.2 cm, mass = 80.7 ± 17.1 kg, experience = 10.6 ± 10.4 years).

Intervention(s): Paired participants conducted 16 trials in random order for each of 4 helmet, face-mask, and shoulder-pad combinations. An 8-camera, 3-dimensional motion-capture system was used to record head motion in live models wearing properly fitted helmets and shoulder pads.

Main Outcome Measure(s): Time and perceived difficulty (modified Borg CR-10).

Results: Helmet removal resulted in greater motion than face-mask removal, respectively, in the sagittal (14.88°, 95% confidence interval [CI] = 13.72°, 16.04° versus 7.04°, 95% CI = 6.20°, 7.88°; $F_{1,19} = 187.27$, $P < .001$), frontal (7.00°, 95% CI = 6.47°, 7.53° versus 4.73°, 95% CI = 4.20°, 5.27°; $F_{1,19} = 65.34$, $P < .001$), and transverse (7.00°, 95% CI = 6.49°, 7.50° versus 4.49°, 95% CI = 4.07°, 4.90°; $F_{1,19} = 68.36$, $P < .001$) planes. Face-mask removal from Riddell 360 helmets took longer (31.22 seconds, 95% CI = 27.52, 34.91 seconds) than from Schutt ION 4D helmets (20.45 seconds, 95% CI = 18.77, 22.12 seconds) or complete ION 4D helmet removal (26.40 seconds, 95% CI = 23.46, 29.35 seconds). Athletic trainers required less time to remove the Riddell Power with RipKord (21.96 seconds, 95% CI = 20.61°, 23.31° seconds) than traditional shoulder pads (29.22 seconds, 95% CI = 27.27, 31.17 seconds; $t_{19} = 9.80$, $P < .001$).

Conclusions: Protective equipment worn by American football players must eventually be removed for imaging and medical treatment. Our results fill a gap in the evidence to support current recommendations for prehospital emergent management in patients wearing protective football equipment. Helmet face masks and shoulder pads with quick-release designs allow for clinically acceptable removal times without inducing additional motion or difficulty.

Key Words: cervical spine injury, sudden cardiac event, protective equipment

Key Points

- Face-mask removal induced less motion than helmet removal when accessing the airway.
- Helmet face masks and shoulder pads with quick-release designs allowed for clinically acceptable removal times without inducing additional motion or difficulty.
- The actual ability to effectively ventilate a patient with a helmet on and face mask removed was not studied and has not been established in the literature.

More than 2 million athletes participate in American football each year.[1] The sport has the highest rate of fatalities and catastrophic injuries of any sport,[2] with most resulting from neurotraumatic (brain, cervical spine) and sudden cardiovascular events. The ability to initiate immediate basic life support in these scenarios is paramount in preventing avoidable sudden death. However, the equipment designed to protect athletes from catastrophic injury challenges the responders' ability to obtain neutral spine alignment and immobilization during delivery of emergency life support. An investigation is warranted of equipment-removal techniques that may be implemented by emergency care providers (eg, certified or licensed athletic trainers, paramedics, and emergency department staff) giving life support.

Acute medical care of the American football player with a potentially catastrophic injury or illness in the prehospital setting (ie, athletic field) necessitates a careful and coordinated approach to minimize sequelae associated with misdiagnosis and mismanagement.[3] The prehospital setting presents unique factors that make delivering appropriate care challenging. For example, given that isolated independent removal of football helmets has been shown to move the cervical spine out of neutral alignment,[4–6] the National Athletic Trainers' Association[7] recommended that the helmet and shoulder pads remain in place and airway

access be achieved via face-mask removal, except under certain circumstances. However, no researchers have published reports comparing helmet removal and face-mask removal to support this recommendation. These recommendations also differ from protocols used by many providers for suspected spine injuries in patients wearing helmets without shoulder pads (eg, cycling, motorsports), when removal of the helmet is necessary to secure airway access and establish neutral cervical alignment.

Recent modifications from 2 football-equipment manufacturers involve helmets with face masks that are attached with a full quick-release system designed to release the face mask without removing screws. Previous systems incorporated quick-release face-mask attachments at 2 of 4 positions and appeared to allow for faster and safer airway access than traditional attachments.[8,9] A manufacturer also has modified a shoulder-pad design to incorporate a quick-release feature. Research validating the safety of these designs will provide evidence to support clinical best practices.

Therefore, the purpose of our study was to determine the safest emergency intervention to allow for airway and chest access in the presence of different styles of helmets and shoulder pads. To accomplish these objectives, we were most interested in the interaction between airway-access technique and helmet type and the effect of shoulder-pad designs on head movement, time to task completion, and perceived difficulty of removal. We hypothesized that less head movement, less time to task completion, and less perceived difficulty would exist (1) during face-mask removal than during helmet removal, regardless of helmet type, and (2) during shoulder-pad removal using a quick-release shoulder pad design versus a traditional shoulder-pad design.

METHODS

Study Design and Setting

We used a quasi-experimental design comparing airway-access and chest-access techniques. The study was conducted in a controlled laboratory setting.

Participants

Our sample was recruited via e-mail from the population of certified or licensed athletic trainers (ATs) surrounding our research institution located in the New England region of the United States. Participants completed a general health-history questionnaire to determine their eligibility for inclusion. Any volunteer with a history of substantial upper extremity or central nervous system injury during the 6 months before the study was excluded from participation. Participants received a modest financial incentive ($30) to assist with travel expenses and 2 continuing education units toward maintenance of their AT credentials.

We performed an a priori sample-size calculation[10] based on moderate to large effect sizes from variables of head motion that have been reported.[8,9,11] Using an α level of .05 and power of 0.8, we determined that a sample of 24 participants (12 pairs) would be needed to demonstrate a large effect. Given that we were exploring equipment that had not been studied, we recruited a conservative sample of 40 participants (20 pairs; 21 men, 19 women; age = 33.7 $\pm$ 11.2 years, height = 173.1 $\pm$ 9.2 cm, mass = 80.7 $\pm$ 17.1 kg, professional AT experience = 10.6 $\pm$ 10.4 years), and 100% of participants completed the study. All participants provided written informed consent, and the study was approved by the University of New Hampshire's Institutional Review Board for the Protection of Human Subjects in Research.

Instrumentation

An 8-camera, analog, high-speed, 3-dimensional motion-capture and motion-analysis system (Falcon; Motion Analysis Corporation, Santa Rosa, CA) was used to record head and torso movement during our trials. We used EvaRT 5.0 (Motion Analysis Corporation) software to track and edit 3-dimensional trials and Kintrak 6.02 (Motion Analysis Corporation) software to analyze head movement. Before each data-collection session, we calibrated a 3 $\times$ 7 $\times$ 3-m data-capture volume using both seed and wand calibration techniques. Ten new ION 4D helmets (Schutt Sports, Litchfield, IL), 10 new Riddell 360 helmets (Riddell SPorts Group, Inc, Rosemont, IL; 8 for data collection and 2 for training), and 2 new sets each of Riddell Power (Riddell Sports Group, Inc) and Riddell Power with RipKord (Riddell Sports Group, Inc) shoulder pads were acquired for the study. Two healthy college-aged male volunteers who were of similar stature and wore appropriately fitted football helmets and shoulder pads served as models to simulate injured football players throughout the study. Analyses revealed no effect of the different models on our outcome measures. These analyses are not included in this manuscript. Each model was outfitted with a 2-segment, 3-point marker set to record and analyze head movement during the trials. The bite marker was constructed of lightweight aluminum and designed to avoid obstructing face-mask and helmet removal. A 1-second static trial was recorded while the model was supine in the capture volume with the marker set in place. A digital stopwatch (Bodytronics 100; TKO Enterprises, Fayetteville, GA) was used to time each trial, and participants reported difficulty associated with each trial using a modified Borg CR-10 scale, which has been used in similar investigations.[8,11]

Protocol

Participants reported in pairs to the biomechanics laboratory at our institution. They completed a health-history questionnaire and informed consent form, and we determined eligibility and recorded participant demographics. The participants were assigned randomly to serve as rescuer 1 or 2, which dictated the roles and responsibilities for data collection in each trial. We provided a general overview of the study, and participants observed specific demonstrations of face-mask–, helmet-, and shoulder-pad–removal techniques used to gain access to the airway and chest. For airway-access conditions, participants were trained in removal of face masks attached to 2 helmets (ION 4D, Riddell 360) with full quick-release mechanisms. Participants also were trained in helmet removal for the same types of helmets. For chest-access conditions, participants were trained to remove 2 shoulder-pad designs using a flat-torso technique: (1) traditional shoulder pad (Riddell Power) and (2) shoulder pad equipped with a novel quick-release mechanism (Riddell Power with RipKord).

Table 1. Step-by-Step Protocol for Participants During the Face-Mask–Removal Conditions

For each face-mask–removal condition (ION 4D[a] or Riddell 360[b]), rescuer 1 knelt behind the supine model's head; the rescuer's start position was with hands at sides. A cordless screwdriver was placed on the floor on rescuer 1's self-reported dominant side. Rescuer 2 was positioned to the side of the supine model and provided cervical stabilization from below. When set, an investigator (S.A.D.) read from a script, reiterating the protocol for the condition. Data collection was initiated by the motion-analysis system using an audio signal that cued rescuer 2 to start. Rescuer 2 then attempted to remove the face mask according to current guidelines or the manufacturer's recommendations.

For the Riddell 360, this involved using the point of the screwdriver to depress a push-button quick-release mechanism from the face-mask attachment points. When the face mask was released, the face mask was placed by rescuer 1 on a designated spot on the floor identified by an *X*.

For the ION 4D, this involved using the screwdriver to turn 2 one-quarter–turn quick-release screws from the top of the face mask and then pulling the face mask out of channels on both sides of the outside of the helmet.

The trial concluded when rescuer 1's hands were placed on the supine model's head to assume cervical stabilization. At this point, rescuer 1 said, "Done," and the trial was considered finished. If the face mask was not placed on the *X* within 3 minutes of the trial start, the trial was stopped, the reason for failure was identified, and the trial was repeated to ensure 2 successful trials per condition and per participant.

[a] Schutt Sports, Litchfield, IL.
[b] Riddell Sports Group, Inc, Rosemont, IL.

The RipKord system weaves a cable into the back of the shoulder pads to keep the left and right sides together. Removing this cable by sliding it out of the groove allows the shoulder pad halves to separate and be removed by sliding them off the upper extremities instead of removing them over the head, as is required with traditional shoulder-pad designs. The helmet-removal conditions and shoulder-pad–removal conditions were performed within the same trials because the removal of one generally dictates removal of the other. A stopwatch was used to record transition times, which later were integrated into the motion-analysis software to delineate motion that occurred relative to the specific task (helmet removal or shoulder-pad removal). Participants were permitted to practice the techniques until they reported feeling comfortable with the expectations. When participants completed the training session, a 5-minute rest period was initiated before data collection. During this time, the 16 data-collection helmets were organized in the random order assigned a priori for that session by using a Web-based random number generator (http://www.randomizer.org).

A detailed description of the protocol for each condition is provided in Tables 1 and 2. Trial setup and participant positioning were standardized for each condition (Figure). After completing each trial (face-mask removal, helmet removal, and shoulder-pad removal), participants were instructed to rate the difficulty associated with the task using the modified Borg rating scale. Participants were shown the scale individually and instructed to silently point to the appropriate rating to avoid influencing the paired participant. We recorded the ratings and times for the trial on paper and set up the next condition.

Table 2. Step-by-Step Protocol for Participants During the Helmet-Removal and Shoulder-Pad–Removal Conditions

Condition	Protocol
ION 4D[a] and traditional shoulder pads[b]	Rescuer 1 stabilized the head with hands on the helmet, and rescuer 2 was positioned to the side of the model with hands at sides. Medical scissors (Super Pro; Pro Orthopedic Devices, Inc, Tucson, AZ) were placed on the floor on rescuer 2's self-reported dominant side. Before the start of the trial, an investigator (S.A.D.) read from a script, reiterating the protocol for the condition. After the audio cue, rescuer 2 unfastened the axillary straps, picked up the scissors, cut the front laces on the shoulder pads, cut the chin strap on 1 side, and pulled the strap away from the chin. Rescuer 2 assumed control of cervical stabilization of the head from the front with forearms resting on the model's chest between the open shoulder pads. Rescuer 1 removed the helmet and placed it on the *X* on the floor. Next, the investigator entered the data-collection volume to assist rescuer 1 with removal of shoulder pads. After rescuer 1's direction, the shoulder pads were removed by spreading and sliding them out from under the supine model's head. As the shoulder pads were removed, rescuer 2 lowered the head to the floor to maintain neutral alignment. Rescuer 1 then resumed stabilization of the head and said, "Done," at which time the trial was considered finished.
Riddell 360 helmet[b] and Riddell Power with RipKord shoulder pads[b]	The starting position for the 2 rescuers was the same as for the ION 4D and traditional shoulder pads. Again, an investigator (S.A.D.) read from a script to reiterate the steps for the condition. However, after the audio cue, rescuer 2 picked up the scissors immediately, cut the front laces on the shoulder pads, cut a plastic fastener on the RipKord cable, cut the chin strap on 1 side, and pulled the strap away from the chin. Rescuer 2 assumed control of cervical stabilization of the head from the front with forearms resting on the model's chest between the open shoulder pads. Rescuer 1 removed the helmet and placed it on the *X* on the floor. Rescuer 1 resumed control of head immobilization, and rescuer 2 pulled the RipKord cable from the shoulder pads. The investigator entered the data-collection volume to assist rescuer 2 with shoulder-pad removal. After rescuer 2's direction, the shoulder pads were removed by pulling the left and right sides of the pads apart and sliding them down and off the upper extremities of the model. As the shoulder pads were removed, rescuer 1 lowered the head to the floor to maintain neutral alignment. When the head rested on the floor, rescuer 1 said, "Done," and the trial was considered finished.

[a] Schutt Sports, Litchfield, IL.
[b] Riddell Sports Group, Inc, Rosemont, IL.

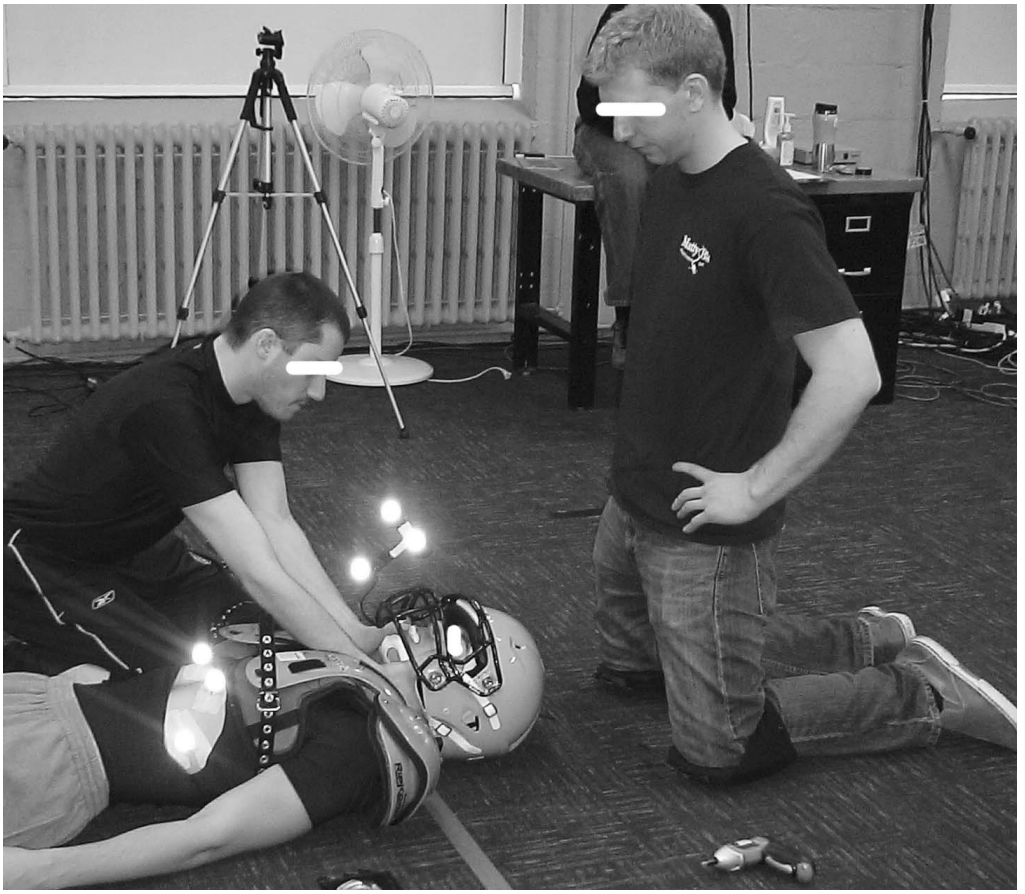

Figure. Data-collection setup with paired participants in ready position waiting for audio cue to initiate removal (in this case, the face mask).

Analysis

Three-dimensional data were tracked and smoothed at 10 Hz using a recursive, fourth-order, low-pass Butterworth filter. Digitized raw x-, y-, and z-coordinates for the dynamic and static trials were exported from EVaRT into the Kintrak 6.02 software program. 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. *Range of motion* was defined as the difference between the extreme ranges observed in each direction of the respective plane of motion. For helmet- and shoulder-pad–removal trials, the recorded transition times were inserted manually into the respective trials within 0.10 seconds accuracy, and range of motion was calculated between transition periods. This 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.

Our study included 3 primary independent variables: airway-access technique (face-mask removal, helmet removal), helmet type (ION 4D, Riddell 360), and shoulder-pad design (traditional, RipKord). Our dependent variables of interest included head excursion in degrees (computed by subtracting minimum position from maximum position) in each of the 3 planes (sagittal, frontal, transverse) during each trial, time to task completion, and difficulty rating. Given our participant pairing, our analyses were based on a sample of 20. To address our objectives, we performed a 2×2 (helmet type by airway-access technique) within-subject repeated-measures analysis of variance for each dependent variable. Paired-samples *t* tests were also used to determine differences between shoulder-pad designs for each dependent variable. All analyses were performed using SPSS statistical software (version 19.0; IBM Corporation, Armonk, NY) with the α level set a priori at .05.

RESULTS

We observed a helmet type-by-airway-access technique interaction for time to task completion ($F_{1,19} = 349.12$, $P = .001$). Face-mask removal with Riddell 360 helmets took longer (31.22 seconds, 95% confidence interval [CI] = 27.52, 34.91 seconds) than face-mask removal with ION 4D helmets (20.45 seconds, 95% CI = 18.77, 22.12 seconds) or complete helmet removal with ION 4D helmets (26.40 seconds, 95% CI = 23.46, 29.35 seconds). Helmet removal resulted in greater motion than face-mask removal in the sagittal plane (14.88°, 95% CI = 13.72°, 16.04° versus 7.04°, 95% CI = 6.20°, 7.88°; $F_{1,19} = 187.27$, $P < .001$), frontal plane (7.00°, 95% CI = 6.47°, 7.53° versus 4.73°, 95% CI = 4.20°, 5.27°; $F_{1,19} = 65.34$, $P < .001$), and transverse plane (7.00°, 95% CI = 6.49°, 7.50° versus 4.49°, 95% CI = 4.07°, 4.90°; $F_{1,19} = 68.36$, $P < .001$). Our ATs reported equal task difficulty across both helmet designs and airway-access techniques ($F_{1,19} = 0.56$, $P = .46$). All

Table 3. Motion, Time, and Perceived Exertion During Face-Mask and Helmet Removal by Helmet Type[a]

Variable	Helmet, Mean (95% Confidence Interval)				Interaction			Helmet Type[d]			Airway Technique[e]		
	ION 4D[b]		Riddell 360[c]										
	Face-Mask Removal	Helmet Removal	Face-Mask Removal	Helmet Removal	Effect Size	$F_{1,19}$ Value	*P* Value	Effect Size	$F_{1,19}$ Value	*P* Value	Effect Size	$F_{1,19}$ Value	*P* Value
Plane range of motion, °													
Sagittal	7.27 (6.15, 8.39)	15.40 (14.19, 16.60)	6.80 (6.01, 7.60)	14.37 (13.01, 15.72)	0.18	0.59	.45	0.51	4.93	.04[f]	3.14	187.27	<.001[f]
Frontal	4.64 (3.89, 5.39)	6.54 (5.88, 7.20)	4.82 (4.27, 5.38)	7.46 (6.83, 8.10)	0.28	1.46	.24	0.66	8.45	.009[f]	1.85	65.34	<.001[f]
Transverse	4.45 (3.96, 4.95)	7.16 (6.42, 7.89)	4.52 (3.99, 5.05)	6.84 (6.13, 7.54)	0.14	0.38	.55	0.12	0.25	.62	1.90	68.36	<.001[f]
Time, s	20.45 (18.77, 22.12)	26.40 (23.46, 29.35)	31.22 (27.52, 34.91)	28.82 (25.64, 31.99)	0.92	349.12	.001[f]	1.43	38.91	<.001[f]	0.26	1.26	.28
Rating of perceived exertion	1.91 (1.62, 2.21)	2.13 (1.72, 2.53)	2.08 (1.67, 2.49)	2.14 (1.75, 2.54)	0.17	0.56	.46	0.16	0.49	.49	0.17	0.58	.46

[a] Statistical results are provided for the interaction effect of helmet type by airway-access technique and main effects for helmet type and airway-access technique.
[b] Schutt Sports, Litchfield, IL.
[c] Riddell Sports Group, Inc, Rosemont, IL.
[d] Helmet-type main effect compared ION 4D and Riddell 360 helmets across both airway-access techniques (collapsed means for face-mask and helmet removal).
[e] Airway-access–technique main effect compared face-mask and helmet removal across both helmet types (collapsed means for ION 4D and Riddell 360 helmet).
[f] Indicates difference.

descriptive data and relevant statistical findings related to helmet type and airway-access techniques are provided in Table 3.

Athletic trainers required less time to remove the RipKord shoulder pads (21.96 seconds, 95% CI = 20.61, 23.31 seconds) than traditional shoulder pads (29.22 seconds, 95% CI = 27.27, 31.17 seconds; $t_{19} = 9.80$, $P < .001$). We observed no differences in sagittal-plane ($t_{19} = 1.63$, $P = .12$), frontal-plane ($t_{19} = 0.80$, $P = .44$), or transverse-plane ($t_{19} = 1.10$, $P = .29$) head motion resulting from shoulder-pad removal between the 2 designs. We noted no differences in difficulty reported by the ATs in removing the 2 shoulder-pad designs ($t_{19} = 0.80$, $P = .44$). All descriptive data and relevant statistical findings related to shoulder-pad designs are provided in Table 4.

DISCUSSION

As hypothesized, face-mask removal induced less motion than helmet removal when accessing the airway, validating current clinical recommendations.[7,12] Furthermore, the magnitudes of the differences were not only statistically different but were clinically meaningful, as evidenced by the effect sizes reported in Table 3. As such, if the goal is to defer the head and neck motion associated with helmet removal until the patient is in the emergency department, health care providers should remove the face mask rather than the helmet from a fully equipped football player in the prehospital setting.

Prehospital face-mask removal not only defers the motion that occurs when the helmet is removed, it also allows for access to the airway in a clinically acceptable time of around 30 seconds or less. The face-mask removal times we observed were similar to or better than those reported by researchers[8,9,11,13] for face-mask removal from other styles of helmets. However, we had hypothesized that face-mask removal would be performed in less time than helmet removal. Face-mask removal from the ION 4D helmet was indeed faster than both helmet-removal conditions, supporting this hypothesis. However, the Riddell 360 helmet face-mask–removal condition took longer than helmet removal did. On closer inspection of the results, we observed that face-mask removal in the Riddell 360 helmet did not take longer than is acceptable or what we expected; rather, helmet removal took less time than we anticipated. The dearth of available literature in which researchers have reported time for football helmet removal limited our ability to speculate on our results or compare them with the results of others. Swartz et al[13] noted that previously suggested steps for helmet removal may not be necessary or even possible. Deflating the air bladders of the helmet adds time to the task and may not provide an additional advantage in helmet removal.[13] Furthermore, not all valves for the helmet air bladders are accessible in a supine athlete. Therefore, we elected not to deflate the air bladders in our protocol. Another commonly recommended step for helmet removal that our participants were not required to perform was to attempt to remove the cheek pads.[7] The style of helmets that we used does not allow for cheek-pad removal when worn by an athlete. Eliminating these steps allowed helmet removal to be performed faster than it would have been if those steps had been performed.

Table 4. Motion, Time, and Perceived Exertion During Shoulder-Pad Removal

Variable	Shoulder-Pad Design, Mean (95% Confidence Interval)		Effect Size	t_{19} Value	*P* Value
	Traditional	RipKord[a]			
Plane range of motion, °					
Sagittal	14.10 (12.83, 15.37)	12.84 (11.89, 13.80)	0.52	1.63	.12
Frontal	6.84 (6.16, 7.52)	6.49 (5.95, 7.02)	0.26	0.80	.44
Transverse	6.92 (6.39, 7.46)	6.52 (5.98, 7.06)	0.34	1.10	.29
Time, s	29.22 (27.27, 31.17)	21.96 (20.61, 23.31)	3.34	9.80	<.001[b]
Rating of perceived exertion	2.13 (1.74, 2.51)	2.28 (1.97, 2.58)	0.26	0.80	.44

[a] Riddell Sports Group, Inc, Rosemont, IL.
[b] Indicates difference.

The full quick-release face mask in both helmet styles allowed for faster removal times than previously reported for helmets with only partial quick-release capability removed from a healthy model.[8,9] Toler et al[9] found that removal of a partial quick-release–style face mask took approximately 50 seconds, whereas Swartz et al[8] noted that removal times were around 33 seconds with the same style. Clearly, the superior face-mask design that allowed the greatest removal speed in our study was the ION 4D helmet, taking only around 20 seconds for complete removal. Whereas it took more than 10 seconds longer on average to remove the Riddell 360 helmet, the times for face-mask removal using quick-release technology in this helmet were improved dramatically over times reported for removal with a cordless screwdriver[9,11] or when cutting a loop strap is required.[14] Helmet manufacturers should consider incorporating full quick-release face-mask designs into any helmets that do not possess the technology and should design all future helmets with this feature. Finally, researchers should continue to examine the effects of helmet designs on viable emergency airway support, as some investigators have explored inserting a pocket mask beneath the face mask[9,15] and using airway adjuncts in a simulation-manikin research model.[16]

Our results suggested that the new RipKord design allows ATs to remove shoulder pads more quickly without exacerbating motion or adding difficulty to the task. We used the flat-torso technique for traditional shoulder-pad removal. Other methods for shoulder-pad removal exist and have been investigated,[17,18] but we are unable to speculate on how the RipKord design might compare with those alternate techniques. Also, many football players wear other shoulder-pad accessories, such as back plates and rib pads. Researchers should study the effect that these might have on removing shoulder pads with a RipKord design. An advantage to the RipKord design is that because the pads are separated and removed from the sides, the shoulder pads can be removed without having to pull them up over the patient's head. Removal in this way avoids accidental perturbations that might result from contacting the head and also eliminates the need for the space that would be required behind or over the athlete to ensure the shoulder pads could clear the head. The ability to do this would become more important during transport in an ambulance or in a small emergency department space where clearance over the head may not be available.

Limitations

We did not investigate these techniques with respect to other brands or styles of football helmets or shoulder pads, and we did not study these techniques in other equipment-intensive sports such as lacrosse or ice hockey. Given the popularity of football and the increasing prevalence of serious head and cervical spine injuries in this sport,[1] we believe our study focus on football was warranted. We removed shoulder pads using a flat-torso technique. We did not deflate the helmet bladders before removal, on the basis of published findings.[13] Our results may differ from other shoulder-pad removal techniques and may be influenced by helmet bladder deflation. Our investigation involved 2 healthy male models to simulate an injured patient. The extent to which our findings would have been affected by using additional models with a greater range of physical characteristics, such as height and mass, is unknown. The extent to which the motion or times we observed would exacerbate a potentially catastrophic injury is unknown, even in light of the clinically relevant effect sizes we computed in our healthy sample. Our research methods limited our ability to establish a relationship between the magnitudes of the differences between conditions with an increased risk of iatrogenic injury. Last, we did not measure the performance differences between ATs with more or less equipment-intensive sport experience, a topic that we believe has clinical value worthy of future study.

CONCLUSIONS

We directly compared football-helmet face-mask removal and helmet removal and filled a gap in the evidence to support current recommendations for prehospital management in football players. Helmet face masks and shoulder pads with quick-release designs allow for clinically acceptable removal times without inducing additional motion or difficulty.

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