DEFENSE CENTERS OF EXCELLENCE
For Psychological Health & Traumatic Brain Injury

Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury (DCoE) Webinar Series

February 11, 2016 1-2:30 p.m. (ET)

Concussion and Winter Sports

Operator: Welcome and thank you for standing by. At this time, all participants are in a listen only mode. Today's conference is being recorded. If you have any objections, you may disconnect at this time. Now I'd like to turn today's meeting over to Dr. Scott Livingston. Thank you, you may begin.

Scott Livingston: Good day and thank you for joining us today for the DCoE Traumatic Brain Injury February webinar titled Concussion and Winter Sports. My name is Dr. Scott Livingston and I am the Director of Education for the Defense and Veterans Brain Injury Center at the Defense Center of Excellence for Psychological Health and Traumatic Brain Injury. I will be your moderator for today's webinar.

Before we begin, I want to review a few webinar details. If you experience any technical difficulties during the webinar please visit dcoe.mil/webinars to access troubleshooting trips. Please feel free to identify yourself to other attendees via the chat box but refrain from marketing your organization or products. Today's presentation references and resources are available for downloading from the files pod and will be archived in the online education section of the DVBIC website. All those who wish to obtain continuing education credit or certificate of attendance and to meet eligibility requirements must complete the online continuing education evaluation. After the webinar, please visit dcoe.dds.pesgbe.com to complete the online CE evaluation and download or print your CE certificate or certificate of attendance. The evaluation will be open through Thursday, February 25, 2016. Throughout the webinar you are welcome to submit technical or content-related questions via the Q&A pod located on the screen. All questions will be anonymous. Please do not submit technical or content-related questions via the chat pod.

I will now move to today's webinar, Concussion in Winter Sports. By way of some general introduction, nearly four million Americans are affected by sport or recreational traumatic brain injuries annually. Winter sports such as ice hockey, skiing, and sledding are often fast-paced, high velocity activities that can lead to serious injury including concussion or mild traumatic brain injury. Surprisingly, head injuries in winter sports have not been studied as frequently as those in football or soccer. The most studies winter sport is ice hockey. This webinar will provide an overview of winter sports injury with an emphasis on ice

hockey research designed to understand injury mechanism, the concussion myth, and prevent novel opportunities for preventing injury.

The objectives for today's webinar are listed here on your slide. At the conclusion of this webinar, participants should be able to describe the epidemiology of winter sports concussion with a primary emphasis on ice hockey, articulate the effectiveness of prevention intervention that would include education, protective gear, and rule changes in organized sport, and employ educational resources to reduce the risks, incidents, severity, and consequences of concussion in ice hockey.

It's now my pleasure to introduce the speakers for today's webinar. Dr. Jason Mihalik is an assistant professor in the Department of Exercise and Sports Science at the University of North Carolina Chapel Hill. He current serves as the Director of the Exercise and Sports Science Musculoskeletal Cadaver Anatomy Lab and teaches courses in Biomechanics and Undergraduate Research Methods and also assists with Graduate Statistics and Research Methods courses in his department. Dr. Mihalik completed his undergraduate degree in exercise science with a specialization in athletic therapy at Concordia University in Montreal, Quebec Canada in 2001. He completed his graduate work in sports medicine at the University of Pittsburgh and earned his master's degree in December 2004. Dr. Mihalik was a recipient of the Dr. Thomas S and Mrs. Caroline H. Royster Jr. Five-year fellowship allowing him to complete his doctoral work at the University of North Carolina at Chapel Hill in the summer of 2009.

Jason's primary research interests including studying the biomechanics related to head trauma and studying common pathways for managing head trauma from the sideline through the emergency department. His secondary research interests include neurocognitive and postural deficits associated with sport-related mild traumatic brain injury and why the postural control strategies investigating the sequelae associated with mild traumatic brain injury in athletes and areas such as postconcussion syndrome and posttraumatic migraine and exploring the potential for concussion rehabilitation in virtual reality environments. He also has an interest in the field management of neurotraumatic spine-related injuries.

Our second speaker for today, Dr. Erin Wasserman is a postdoctoral research trainee in the Department of Exercise and Sports Science at the University of North Carolina Chapel Hill. She completed her undergraduate degree in Biology and Heath and Society at the University of Rochester in 2009 and her doctoral training in epidemiology at the University of Rochester School of Medicine and Dentistry in 2015. Erin's research interests include the prevention and management of concussion and identification of demographic, clinical, and biomechanical risk factors of concussion and poor outcome following injury.

It is now my pleasure to turn this over to Dr. Mihalik and Dr. Wasserman for their presentation.

Jason Mihalik: Thank you Dr. Livingston. Erin and I would to like thank DVBIC and DCoE for the opportunity to present this webinar, Concussion in Winter Sports to all those that are attending and by my count it looks like we've exceeded a hundred on the webinar, fantastic. Before we move forward in the presentation, I would just like to make a few disclosures. The views expressed herein are mine, they don't reflect the official policies of the Department of the Army, DOD, or DVBIC. I don't intend on discussing off label or investigative use of the commercial products or devices that may be discussed here in the presentation. In addition my hat as academic researcher here at the University of North Carolina Chapel Hill, I'm also the Chief Science Officer for a startup company called Synaptic and I have also co-authored a couple of smart phone apps.

Skipping ahead here to the moving brain but Erin was going to make her disclosures and hers were that there were none and that last disclosure that I had on my slide does not apply Erin. She is disclosure free. What you're seeing on the screen here is a pretty good graphic to describe what's actually occurring with concussion. Typically, the human is moving whether it's down the field, down the ice, down the ski slope, what have you and it moves at a pretty high velocity and it comes to a sudden stop. When the brain or when the skull comes to a sudden stop, the brain inside continues to move kind of back and forth in a coup contrecoup mechanism which you're seeing here in front of you on your screen.

The idea there is that helmets and other equipment, we'll talk about those later, do a really nice job of protecting the skull the forces will still penetrate and will still cause the brain inside to bounce back and forth. It's kind of like a school bus effect where if the bus slams on the brakes, the passengers still have that forward momentum even though the bus has come to a sudden stop. Until we can really stop that brain from traveling inside the skull, we're going to have a really hard time preventing all concussions from occurring. Another key distinction with concussion is that the majority of them don't result on positive findings on CT or MRI scans. The idea that someone has sustained a potential head injury, goes to the emergency department, has a CT MRI that comes back clear doesn't mean that person hasn't sustained some form of a head injury, he just hasn't sustained one that's serious enough to cause a catastrophic outcome but concussion can still certainly manifest there.

If we can forward to the next slide. A concussion is no short order. There are upwards of 3.8 million as you heard in the introduction and almost 4 million recreational and sport-related traumatic brain injuries occur in the United States each year. Certainly that number grows considerably when we factor in international counts as well. It's a big problem. Some data from the CDC that has been published specific to traumatic brain injury. It is a cause of death. It is a major cause of hospitalizations and emergency department visits. One area that is of most concern to us clinically is the number of people that are either receiving other medical care that we can't track or we can't monitor or supervise and perhaps importantly the percentage of folks that are injured that aren't seeking care at all and that's a really big concern for us. In the clinical

space, we want to make sure that athletes who are symptomatic following concussion are being managed appropriately and without the means to track that and to know the true exposure behind this it's going to be a very difficult clinical condition to wrangle.

It's an expensive condition. Upwards of 56 billion dollars go towards direct and indirect costs related to managing TBI in the United States every year. In our state alone, in North Carolina, we're looking at a cost that exceeds almost 200 million dollars a year. It's a really large impact to the healthcare system and we need to find better ways to mitigate that.

As a result, people are interested in learning more about concussion and studying it and what you're seeing here is just a very basic graphic to depict the numbers for concussion publication that have been indexed in Pub Med. If you look in the first decade of the 2000s, the second bar from the right, in that one decade we had more publications on sports concussion than the four decades combined that preceded it. So far, only half way through this decade we've almost tripled the amount of publications that we saw last decade. There's this exponential growth in the interest and the ability to study for concussion and to derive some very important answers to some of the clinical challenges that we're seeing as a function of this injury.

It's not surprise as we grow and understand more about TBI and specifically concussion, we know that there are so many aspects and so many facets of the injury that contribute not only to our understanding of the injury but then also you have to factor in from the standpoint are you treating and managing and assessing and possibly even rehabbing some of athletes and our soldiers that have suffered concussion. We know that cognition is affected following TBI. We know concussion history can play a factor. Those with a previous history of injury are more likely to sustain subsequent injury and also more likely to suffer a longer protracted recovery as a function of those injuries. We balance can be a fairly good objective measure and mechanism of injury, which is the focus of my research studying the actual biomechanics or the causes of the injury. This is one area where I feel we can intervene on and hopefully prevent some injuries from needlessly occurring.

Our ability to evaluate and assess injuries has grown considerably over the last decade. Our ability to perform a very thorough physical exam has been improved as a function of the research and of our clinical experiences. We're asking the appropriate questions. I think clinicians for the most part are better today than they were ten years ago but we still have a far way to go in getting everyone up to the same standard. We know athletes are symptomatic but what we're trying to understand now is what specific clusters of symptoms might predispose an athlete or a soldier to a delayed recover. What specific cluster of symptoms can we intervene on early so that we don't have an athlete or soldier experiencing a protracted recovery.

We acknowledge attitude and behaviors. There are 50 states and one district that have concussion management laws in place and all of them or the majority of them have some form of required education. The idea and perhaps it's a little altruistic is if we enhance knowledge, if we can put information in the hands of people, we're going to change the way they report or behave around this condition and we're not seeing that link. Just because we're increasing knowledge doesn't mean that we're changing the attitudes and the behaviors of the athletes and the soldiers. That's been a big part of the area of work that some faculty in my research center have been working on and actually just recently got funded by the NCAA and the DOD to take a look at how knowledge, attitudes and behaviors can be affected and how we can better understand culture in a college athlete setting as well as a West Point kind of military academy setting.

Aptly colored black here is treatment. It really is the black box right now. We don't know how to treat athletes because every concussion is different, it's kind of like a snowflake. Until we can get a better idea of what specific clusters and groupings that we see at onset of injury and can predict the long-term consequences only then we will be able to cater specific treatment and individualized treatment programs for those athletes and those soldiers.

Erin Wasserman: As was alluded to in our introduction, winter sports are pretty common but we don't really know very much about how many concussions are happening in winter sports. One of the reasons for this is that if you look at this list of sports they're most things that you do recreationally rather than in governed body such as a formal league like the NCAA or high school. What we are seeing is that there's a wide variety of incidents of concussion or head injury in these sports. Anywhere from 6 out of every 100 athletes who freestyle ski professionally can sustain a head injury whereas we see in luge about 5% of all luge injuries are head injuries.

What's really important from a research standpoint is that there is no standardized measure of head versus concussion in these sports and as you can see, it's not really directly comparable. In some sports they focus on percent of all injuries and in some they report on the actual number of athletes who are sustaining concussion. Until we standardize this and have better data collection, we really can't begin to allocate resources or report appropriate treatment and knowledge of concussion in these sports.

The sport in which we have the most information is ice hockey. It's much more organized and it goes as you can see here, starting in the youth level all the way through the National Hockey League. What's important to note on this slide, you'll see rates per 1,000 player hours. How many concussions out of every 1,000 hours a player plays. We also have this term called athletic exposure, which is one athlete participating in one game or one practice. This could be 10,000 athletic exposures could be 10,000 athletes participating in one game or one athlete participating in 10,000 games or somewhere in between.

What we see on this slide is that as the level of play goes up from youth to high school to college to professional, the incidents of concussion increase so the risk of sustaining a concussion is higher as the level goes up. What we need to find out next is why that might be the case. Is it a change of schools? It is a change of body type? The other important thing to note is that in many sports and you can sort of see it here although the evidence is not as clear, females are often more likely to sustain a concussion than males given the same sport and the same comparable scores. That you can see in the youth level. It looks like the proportion of injuries is higher in females compared to males but not necessarily the rate.

Some research has looked at what factors are associated with sustaining concussions and what makes you more at risk. At the youth level, there has been some research that shows that maybe athletes are more likely to sustain concussion in tournaments versus individual games or practice. That might have something to do with fatigue or the combination of having multiple games in a row. There has been some research out of Canada that shows that concussion rates are lower in non-checking people under 12 years compared to those where checking is allowed.

Then when you forward these athletes forward when they get a little bit older, players who have experience checking in the prior league actually have a lower rate of concussions once they get to their higher level compared to those who have never checked before. In high school boys we see that most of the concussions are sustained on player-player contact or running into each other. The second most common is running into a board or glass. The activity most commonly associated with sustaining a concussion is being checked or skating.

Once we get to the college level, we can compare men and women. You see here that 24% of men who sustained a concussion in college received it because they were contacted by a player while checking and 23% was during general play. In women's ice hockey, checking is not allowed so that factor is no longer part of the piece of the puzzle for a concussion at least on an official basis. We see that player contact during general play is the most common.

My particular interest is what happens after they have a concussion and how is that different across levels of play and across the genders. We see in high school we only have information on boys. About 55% reported that all their symptoms had gone away within six days. If you compare this to the college level, it was only about 25% who had symptom resolution. At first glance this appears like maybe high school is recovering faster than college. What's important to note here is that these studies were done at different time points. The study in high school was done in 2008 and 2010. The college study was 2010 to 2015. It really reflects a change in the knowledge and symptoms reporting we think among athletes. As you know, this is a very important piece of the puzzle. We need athletes to be honest about what symptoms they're experiencing so that we can help them out.

Jason Mihalik: Ideally, in a perfect world we would just prevent them all and then not have to worry about how to deal with them when they happen. It's a bit of a tongue in cheek comment but there are a number of ways that have been proposed to prevent concussion and right now it's more meant than anything. I just want to take the few slides to kind of clear the air on that

The first thing that often comes to mind is the helmet, right? We need to build a better helmet to prevent concussion. I think one of the major take home points here is a helmet is designed to do two things and it does them very, very well. The first thing is to keep you alive and the second is to keep you recoverable. Helmets do a fantastic job of that. If we look to American football, I know the focus on this talk is winter sports but if you look to American football as a model, athletes were dying upwards of 20, 25, 30 athletes a year and then we implemented helmet standards and now we see fewer than 3-4 in a season. It still happens but certainly at a much, much lower rate than what we were seeing previously. Helmets do a really good job of keeping the athlete alive and recoverable and it's able to do that because of the function of how it's developed and the technologies that go into it.

I mentioned the school bus analogy earlier. Think of the helmet as the crumple zone and the airbag as the body. The driver is still going to lean forward but there are mechanisms in place that prevent serious catastrophic injury to that driver but the driver is still going to go forward and bounce forward and backward and may very well still sustain a concussion. Again, a concussion won't kill you unless it's mismanaged and even then the risk of a condition that's called second impact syndrome is one that's quite rare.

At the end of the day, there are a lot of things that can happen on the field that can kill you in contact sports whether it's skiing or hockey or football. The helmets that are mandated and standardized to be worn in those settings are designed to essentially prevent you from dying and I think that's a good thing and we should embrace that. There are no concussion proof helmets. In order to design one, Dave Paul said a friend of mine and a mechanical engineer refers to the material we would need to design a helmet as unobtanium. Quite frankly, we're not at point now where we have that material.

Whether we had a perfect helmet or not, the key here is that we would need to wear it properly. You're seeing a helmet kind of floating in the air here facing the left, it's coming from a player who is facing the right. Not only is this helmet not on head but it's completely flipped around and turned around. This helmet could be the best helmet possibly but if it's not worn properly, it serves no protective benefit. We also need to keep that in mind as well.

Another consideration is the youth athlete. There are no youth helmet standards. Right now the industry is essentially treating little kids as little adults and we'll touch on that topic later. The helmet that this child wears meets the same standard as an adult's helmet. The question that we're asking ourselves is, is the tolerance to head trauma the same as the pediatric athlete as it would be

an adult athlete? I think we generally agree that it probably isn't the same but we don't have the data yet to support what that standard at the youth level should be but that's another consideration.

Another are of prevention is that of mouth guards. The reason I really like this picture is because I think it clearly depicts how a lot of young hockey players particularly use their mouth guards as a three-dollar repeated use piece of chewing gum while they play. The idea behind the mouth guard is essentially that it provides some space in the temporomandibular joint to offset the force loading that comes in through the jaw. In theory it makes sense but in practicality it represents such a small percentage of impacts that are imparted to the head that it would be nowhere near preventing the amount of injury that we would hope it would do.

In hockey, particularly at the youth level, they wear full face masks so it really brings into question the notion of the practical use of the mouthpiece because the idea that it would impact the face mask is anchored by J clips on the side of the helmet and those forces get dispersed to the helmet and not to the head. In the youth hockey model, I'm not sure how effective the mouth guard is and in general terms, there is no scientific data to support the mouth guard as a preventative tool for concussion. However, that being said, there's a pile of research that supports its use for preventing and maxillofacial injury. If your kid has braces or you don't want to chip teeth, by all means wear a mouth guard and use it wisely for that purpose but don't use it with the idea that you're going to prevent concussion because quite frankly you won't and the research doesn't support that.

Another area of prevention will touch on some areas where the coach can play a role. Here's a picture of me when I was a little younger and had a little bit more hair coaching ice hockey. What I did as a coach was really trying to build safe playing techniques. I think from a preventative standpoint, a coach actually plays a more important role than he or she might think that he or she is capable of doing.

As we move forward trying to understand mechanism of injury and preventing injury, we talked a little bit about head impact biomechanics and of course this is not one of our animal model studies that we're doing but just to kind of drive home context that we take our work here at UNC very seriously. We've used a lot of different systems to measure and document frequency of impact and the severity of impact. Some of them are pictured here on the screen.

You may be familiar with the head impact telemetry system which is the device you're seeing on the top left of the screen with the helmet and the red circles. Those represent accelerometers. There are six single axis accelerometers. Those accelerometers are pieces of equipment that measure acceleration and so by embedding them in the helmet, we're able to measure head acceleration that's occurring in real time. The data get transmitted to a [inaudible] system. From a research standpoint, we can view the data in real time but we can certainly

export and analyze the data at a later time to analyze group differences and trends that we're seeing in the data to impact some important rule changes.

Other systems that have been used, the X2 Biosystem is the black patch you see affixed to the mastoid process right behind either the right or the left ear. The G Force Tracker, the red device on the far right is another product. In the context of youth ice hockey and some of the work we've done in winter sports, we worked with Symbex the company that manufacturers the system and we've actually custom installed the accelerometers that you see in the football helmet inside an ice hockey helmet. Under A is the outside part of the inner liner of a helmet. You can see all the wiring and the telemetry. B is the picture of the inside of that foam liner and then C is just a picture of the helmet assembled and you can see some subtle cues there as to where those accelerometer devices are.

Erin Wasserman: Although concussion is a major public health problem, from a research standpoint it still is relatively rare. What we want to know is are these impacts that we're sustaining to the head leading to concussions down the road and also can we prevent harder impact from occurring and therefore maybe also prevent concussion from occurring.

One study we did was looking at the impact to the heads of youth ice hockey players. Using that system that Jason just showed you, we had youth ice hockey players 13 years old wear these helmets. The first thing to do was just to measure what kind of impact are they sustaining and what was really interesting is that we found that hits to the top of the head were of much higher magnitude that hits on the other parts of the head. Also, the average one year acceleration that the 13-year-olds were sustaining was about what we see in college football players. What does that mean for this 13-year-olds who are sustaining these hits? As this picture aptly shows and as Jason mentioned earlier, youth ice hockey players are not just mini adults and while they play in similar ways to NHL players, what risks are associated with the fact that their bodies operate differently than that of an adult.

The next study that Jason actually performed was looking at whether an infraction in youth ice hockey was associated with head impact severity. There were plays in which athletes were hit illegally associated with worse outcome following the hit. In this study he showed that those illegal hits were actually associated with harder impact in linear acceleration. What was also concerning is that 17% of the impacts that the players sustained were illegal which shows there is definitely some room for improvement and enforcement of rules and teaching of proper playing techniques.

Here is a video of a play in ice hockey and if you'll just watch carefully you can see that the player was not anticipating the hit at all. We see this play which was at the youth level, we have a player coming down the ice and obviously was looking at the puck and not at the player coming at him. A very important thing that you see here at the end is that you have a man in jeans in skates running

out here to help the youth ice hockey player. In the NHL, we have lots of medical personnel available to help evaluate athletes and treat them but at the youth ice hockey level, there is often not a medical professional available to evaluate these injuries.

Based on these studies where we see these hard impacts where athletes are not paying attention, we performed another study when he had video in youth ice hockey. Again the players are wearing those helmets and looking at collision time and anticipation. What we saw is that players who collided on the open ice had much higher linear acceleration to their heads than those who collided hear the board. Also, unanticipated hits tended to have harder hits that those that were not anticipated.

Jason Mihalik: Since anticipation seems to play a role in frequency as well as the magnitude of the impact sustained by young hockey players and football players, we have some publications in that area as well. The idea from a preventative standpoint is how can we enhance visual function. How can we teach athletes to anticipate those collisions a little bit better. While an athlete is performing their activities and this is true of military personnel in combat environments and training environments they need to be able to identify static and dynamic features. Being able to distinguish between objects that are moving and those that aren't. They need to be able to scan and interpret visual information, not just from that that's in front of them but also looking out into the periphery as well.

From a sports standpoint, being able to alternate between varying distances, close near objects and far objects. Ultimately, you want to train them to perform efficient eye movements and then from an injury prevention standpoint being able to respond quickly to those visual stimuli. In the world folks are walking around or they're participating in their activities and there's constant sensory input and that sensory input needs to be interpreted in a meaningful way so that they can anticipate a collision or some injurious event if you will. The idea then being that they would then contract cervical muscles which would then reduce the effect of the head impact severity. The idea being there that if you contract the neck muscles strongly enough, the force of the collision isn't just moving the mass of the head but now you're moving an effective mass of the head, neck, and torso segment. It becomes a lot harder to move that greater mass and so you would see a lower acceleration, which we believe to a lower risk of injury.

There are ways that we can evaluate and improve vision. I mentioned the disclosure earlier with my involvement with Synaptec. Synaptec has licensed a patent portfolio from Nike who developed the SPARQ Sensory Performance. The only reason I bring it up is because the SPARQ Sensory Performance Station is actually installed in a lot of elite athlete performance centers as well as a number of high level elite war fighting units across the country whether that be USASOC or Navy Special Warfare. Some of you may be familiar with it or be in environments where you might not even know that they're using this from a

performance standpoint but it's one tool that can assess, analyze, and then provide some training in the vision space.

A lot of them to look at a couple of hardware processes essentially looking at visual acuity and contrast sensitivity and then there are a number of tests that assess the software if you will, the ability of the brain to process visual information and then respond accordingly. You see the gentleman on the top of the screen here performed an eye-hand coordination test where a lot of these circles will light up and they'll have to see the circle, see where it is, obviously respond as quickly as they can and then strike the target. The picture on the bottom doesn't really describe it too well but this gentleman is wearing stroboscopic glasses. The glasses will flicker opaque and clear repeatedly in intervals that you can control. The idea there being that if you can limit visual information and still have them achieve the outcome, they don't need as much visual information the task after their training. When you lift the glasses and they see the whole world again, they're spending so much time looking at a target, they now have more time to look at other distractors or other potential threats in the environment.

We've done a number of papers, a number of projects looking at this from the standpoint of the Sensory Station. We've compared it some of the technical analog measures of vision that might be used in a clinical setting and they match up quite nicely. We also had this idea that vision sensory performance might actually explain what's going on on the field and so in a cohort of college football players, we assess everyone on the vision sensory performance platform. We then categorize them on each of the measures as a high performer or a low performer and then looked at measures of head impact biomechanics because all of these football players also wore that hit system I described, the device with the little red circles on it, in the field.

What we were able to do is on a number of measures identify that those that were poor performing on those measures actually went on to sustain more frequent head impacts and more severe head impact than the ones that performed on that vision sensory performing measure. The idea being here that maybe down the road we can develop this as an injury prevention tool by identifying athletes ahead of time who might at risk of a kind of vision dysfunction and how it might relate to athletic endeavor.

There are a number of ways that we can train anticipation and improve player safety in my opinion in ice hockey. This is picture is no more just to describe the size of the rinks. The traditional ice hockey rink is smaller than the Olympic-sized rink so one area of discussion and obviously the cost of this would be immense because we would have to really modify the infrastructure to use ice hockey and ice hockey facilities in North America and quite frankly in other parts of the world as well but the Olympic is wider and longer and provides more space. The idea being that there would be less likely an opportunity for collision whether it's purposeful in the men's game or inadvertent in the female game that could cause injury.

There's been a long time debate over the skating and the technical skill of European and Russian players compared to the more physical nature of play of North American players and one reason is in North America you can't escape your opponent. You have to run into him or her in order to get around them or through them because they're confined in a smaller ice surface. That's just one area where we might see a lower injury by expanding the playing surface and emphasizing skill.

Another is contact is inadvertent, it's going to happen, it's part of the game. It's allowed as part of the game and USA hockey has actually done a very nice job of promoting small area competitive games where you take three-on-three play in a very small area of the ice. There's not enough room for the players to gain momentum and hit each other in an injury causing way but it promotes them to move the puck quickly, anticipate the collision. When you bring them onto a bigger surface and they're able to hopefully see the play better and accommodate and protect themselves in a much different way. That might be one area of work in ice hockey as well.

This is not a picture mistakenly included in the presentation but I bring it as a radical way of teaching athletes how to skate with their heads up. Erin mentioned earlier in one of our studies we found that a higher than we anticipated prevalence of impacts to the top of the head. While we anticipated that football because athletes often drop their head and hit with the top of their head, we didn't really expect that in ice hockey they typically don't do that.

When we thought about it, we realized that these young hockey players may not possess the technical skills to skate with their heads up and still have a good feel of where the puck is. A lot of these athletes that possess the puck often look down towards the ice as an added level of confidence or awareness of where the puck is and whether they still have possession. If you're looking down to the ice and you expose the top of head and if you're getting struck then that will be recorded to the top of your head. That's probably why we saw such a high percentage of those impacts occurring to the top in a sport where we really didn't think there would be that finding.

The purpose of this picture is when I first arrived in North Carolina and I coached a youth hockey team, I noticed that these kids who were 15-16 years of age were skating with their head down and that really concerned me. There's discussion about bringing these players up north to play in hockey tournaments against kids in Michigan, Massachusetts, and Canada and I actually worried for them because 15 and 16-year-old skilled hockey players are really good and skate with their head up and I really didn't want to put our athletes at risk.

It turns out one of our parents was a vet, a veterinarian I should say not a vet, that would be confusing the audience that talking to today. I asked her to bring in a few of these scratch collars and she I was absurd and I probably am but we had a few of the players where them during practice and what it forced them to do was look in front of them because if they looked down they would be

obscured. The scratch collar would essentially obscure their vision of where the puck was on their stuck. If they couldn't see the puck, they just looked in front of them. That year we were fortunate, we didn't have any concussions. I'm not going to attribute it to the kind of scratch collar training of you will but it's just one example of how a coach can intervene and work with athletes and teach them proper technique to mitigate the risk of injury in a contact sport.

Erin Wasserman: We talked about some ways to improve anticipation and ways improve player safety in their play but as I have mentioned before, there are also ways to change the rules in order to prevent concussion. We talked about some hits that were caused by infractions that were harder and then the study out of Canada and then we've also done some work in youth hockey. There was an issue what I described in Canada where we had some players who were permitted to body check in their peewee years so when they're 12 or so. Then we had other players who were not permitted to body check when they were younger. What we have here is you can see that the pre-group who were permitted to body check once they reached the 14 level actually had less severity of their hits compared to those who did not body check. We found that maybe there's a motor learning component where they learn younger to body check appropriately and therefore can better anticipate hits and still see the hits coming.

Then we also looked at boys versus girls. In boys body checking is allowed but girls they're not allowed to body check. Here you see that the girls are actually sustaining higher level hits than the boys. The next question is, why is this happening? It's not a large difference but overall this is something that we've seen. Some questions we have maybe it has something to with neck musculature, maybe it has to do with the fact that they're not anticipating the hits when they're receiving them and so those are some questions we have.

Jason Mihalik: The idea now is what do we do with all of this information? We know concussions occur. We know people can play a role in improving outcome. We know that some rule changes are effective and others maybe not so much. Where do we take this information and move forward with it? There are a couple of projects that we're working on. This one here is what we refer to as B mod or behavior modification. It is not a project that's being done in a winter sport. It's one that's being done with local high schools that we work with here at UNC Chapel Hill. We're using instrumentation to identify athletes who are tackling perhaps improperly. We're looking for athletes are sustaining injury. We're looking for athletes that are hitting with the top of their head more frequently than they should. We're also looking for athletes who are sustaining more severe impacts than their peers. We're identifying those athletes based on the technology and then we're matching those images that you see here on the middle of your screen to some of the video that we're capturing of those athletes during practice and during games and we're intervening with the athletes.

We're working with the coaches to show them object impact data alongside video of improper technique and using that to reinforce safe blocking and safe tackling techniques with the idea that they then go back to practice and [inaudible] tackling a safer way but just as effective from game performance standpoint so that we can mitigate, we not be able to reduce the frequency of the impact but we can certainly reduce the severity of each of those [inaudible] as they're occurring in practice. We've done this with a number of our college athletes which you see here a picture on the left and right now the actual project that's funded by the CDC is focusing on this group of high school players that you see on the right. Again, that project is funded by the CDC and the National Center for Injury Prevent and Control in particular. It's a three-year project and we're just currently wrapping up our first year of the project.

I know there are a large number of folks that are in attendance today that have a more of a military perspective. Some of our work is being innovated into the military space. We have the humble good fortune of working with some very elite war fighters within the armed forces, working a group of operators within the US Army Special Operations Command. What we're able to do is kind of bring them in small groups and put them through a fairly robust baseline testing program as far as their traumatic brain injury [inaudible] that is probably unlike what we do with any other cohort that we've ever worked with. We traditionally do symptom inventories, cognitive testing, and balance testing but as we go through the next few slides, you'll see that we're doing quite a bit more with these military operators.

One component to is neuroimaging. We're performing structural and functional imaging. We're looking at aspects of brain structure but then also looking at diffusion tensor imaging and I'll touch base with that shortly. We're doing a panel of plasma serum biomarkers. We're assessing vision sensory performance which they've been using from a performance standpoint, we're trying to evaluate its efficacy in identifying deficits following concussion. Instead of training vision performance, we would essentially be rehabilitating them to get to where they were in addition to PBI measures that we typically employ as part of our baseline testing.

With diffusion tensor imaging, what we're able to do is kind of strip away the gray matter and really take a look at the information superhighway of the brain looking at the ability for essentially information to travel without much impedance along the white matter tract. A lot of it is tract-based analyses but they partly were not just looking for structural injury, we're looking for how the brain functions and that's an added level of advanced research that just hasn't really be done in the past. It certainly hasn't been done in this cohort and certainly has been done to the magnitude of baseline testing 170 operators over the last three years and being able to track what their brain function looks like post TBI.

Quite fortunately for the health and well being of the operators that we work with and op tempo for the unit that we work with, there have not been a lot of

injuries so we've been very fortunate in that regard but that also limits our ability to study the ability of these advanced research imaging protocols to help us identify perhaps maybe in real time or at least in the short term athletes that are [inaudible] and how we might be able to curtail them toward specific protocols.

From a biomarker standpoint, my opinion, I think it's the holy grail. The DOD has poured a lot of money into developing our understanding of these blood biomarkers. We know that different blood biomarkers and this isn't my area of expertise but we know that there are markers that have bigger promise to be a cue biomarker. In other words, to identify someone as injured. Then there are subacute and chronic biomarkers that we might be able to use to better understand those individuals or to identify those individuals that might be experiencing and protracted return. Perhaps maybe if we have an understanding of how these biomarkers function in both of these phases at some point develop some pharmaceutical interventions that might help offset some of the long-term recovery issues that we're seeing in the select few patients that we work with.

I mentioned the plasma serum biomarkers. Again, some of these are [inaudible 00:50:53] and cynical. Others are more targeted towards the brain pathology. Again, it's an ongoing process and we don't have any data to share with you at this point. We just wanted to share that we're doing the study.

I mentioned the sensory station earlier. Again, this is part of our vision sensory performance testing that we're with the operators. In the last year, we've been able to start forming a project around blast exposure to some of these other metrics. We've been following this cohort clinically. A concurrent effort between USASOC and DARBA saw these same operators wearing B3 blast gauges on their person while they were training and they're deploying and we had the opportunity last year with some stimulus funding from DARBA to start linking blast exposure to some of the clinical outcomes. Again, there is not much data to share with you in that regard. As I mentioned earlier, quite fortunately the unit has been relatively healthy from a brain injury standpoint. As we start looking forward to future projects and initiatives and potential funding we're going to be looking at aspects of their training that are blast heavy if you will, reaching heavy ordinance firing, those sorts of things to see if we can pick on some of the subtle deficits that those types of activities might be causing from a brain health standpoint.

With these blast gauges, I'm going to source Dr. Rogers who was formerly at DARBA now at Cal Tech. We're able to take information from these blast gauges and reconstruct certain scenarios. In this case, here's a vehicle that drove over an IED. The IED was on the right side of the vehicle. You can see on the picture on the far the individual with the red exposure on his back was the one that was most exposed, the IED was on that side of the vehicle. One of the individuals had their right foot hanging out of the door of the vehicle and so you can see that exposure there as well. For the most part, the other passengers were fairly

protected by the vehicle that they were in and the passenger on the top left of the vehicle was also protected from the left owing to the position that they were seated. Again, we take this information and link it back to some of their baseline neuroimaging and biomarkers and vision sensory performance data to start doing a machine learning approach to figure out which of the operators will be safe in certain environments and certain conditions.

There is a natural between the NCAA and the Department of Defense as far as the types of research that are being done. Obviously, from an athlete's standpoint we could focus on impact injury which is the leading of head trauma for DOD personnel but we can for the blast. Obviously blast exposure doesn't occur in a college sports setting or in a youth sports setting and certainly does and that's one of the unique traits for a lot of TBI causing events in defense operations if you will.

There is a joint funding initiative called the NCAA DOD Grant Alliance being provided by the DOD as well as the NCAA to study college athletes and those cadets and athletes at the military academy and air force academy, and naval academy to really start mapping out what is actually occurring in these soldiers and these athletes in the short term following concussion, looking at concussion recovery trajectories. The idea is that we're building this really massive data set that one day we'll be able to track these athletes in time and look at what the implications today had on their mental and cognitive and neurological well being many years into the future.

At the end of the day, I study head trauma. That's what I do but I also play sports. I played hockey my whole life. I'm a native Montrealer. I still play every Sunday. I think there's a lot more value to be had by participating in sports than not. I do think that there are aspects of sports that can continue to be intense so that athletes can participate longer and safer. At the end of the day, sports do teach us a lot of valuable lessons and I'd be remiss to say that are data don't support getting rid of sport or drastically changing it. I think our data has good precedence for informing good evidence-based rule changes that minimize and mitigate risk associated with participating.

We have a pretty big team here at Matthew Gfeller Center. Our faculty and postdocs are nearing their first [inaudible 00:55:52]. We have own army here of doctoral students and postdoc trainees and the number of undergrads that constantly help us with our projects. On any given day, we probably have about 30 individuals that are in our employ or that volunteer in our center. The work that Erin and I shared with you today certainly isn't just the work that she and I have done on our own. It takes a group of individuals that are focused and dedicated on a mission to achieve the outcome that improves safety. It's definitely a team approach here and I just wanted to share a little bit of background about our team with you before we wrap things up and turn it back over to Dr. Livingston to moderate the question and answer period. Thank you for your time and attention. Erin and I are excited to see what kind of questions come up.

Scott Livingston: Thank you very much, Dr. Mihalik and Dr. Wasserman. Now is the opportunity for our virtual participants if they questions to enter those into the Q&A pod on your screen. We have a number of questions that have come in so we'll start addressing those and continue to monitor questions for the next several minutes as they come in.

The first question, I don't know that it's directly specifically for Dr. Mihalik or Dr. Wasserman so either one of you who care to answer, have some input on it. I'm going to take the liberty of kind of paraphrasing a little bit. This question deals with the concussion frequency rate in comparing youth to high school to professional ice hockey players which was one of the earlier slides in your presentation talking about the injury rate. Is there a critical age threshold that is associated with ice hockey players being at greater risk at the youth sports or getting into the high school, college, and professional of sports.

Erin Wasserman: Actually, as you say on the slide it's a pretty gradual increase just steadily over time but we do need to caution in that there's really limited studies in the youth setting, only a couple. I guess our group and a couple of other groups have actually looked at this. The NHL data are also often protected. Our best data are from high school and college. Until we can have a directly comparable time frame of studies both within 2010 to 2015, it's hard to really say if there is a true rate difference. It really seems like it's steady as age increases so there's the incidence of concussion.

Scott Livingston: Thank you for that answer. The next question that I wanted to bring up that came from a virtual participate is at your center at UNC Chapel Hill, I'm going to make the assumption that this is pertaining to the college athletes there in your program. What does appreciated baseline testing include? Is that just a neurocognitive assessment or are there other components that are used included in that baseline battery? Things like some of the visual balance testing measures that were mentioned.

Jason Mihalik: That's a great question. What I highlighted towards the end of the talk is what we're doing with our USASOC operators. That's certainly high level work that we're doing. What we typically do with our college athletes when they enter in UNC as college first years is we'll complete a computerized neurocognitive test. We'll perform balance testing and we do use a neurocom with them. We administrate the SOT as the test that we do with them for balance. Our neurocognitive platform allows us to kind of customize some questionnaires and history. We get a lot of background about injury history, demographics, family history of a myriad of conditions. Also, with our symptom inventories and so forth. That's the crux of our standard testing. If an athlete comes in and has some history of vestibular issue or some history of ocular motor issue, we'll expand the baseline at the discretion of the team physician to also include some of the other metrics that we described earlier.

Scott Livingston: Thank you. The next question pertains to some of the head impact telemetry data and I know this was discussed quite a bit in the presentation. Overall, has

effective has some of that research on head impacts really had an effect on decreasing concussion risk? Is that something that's clearly well known or still in the preliminary stages of application of the head impact data to decreasing concussion incidents?

Jason Mihalik: The head system data and data from other devices really to be honest have informed a number of good policy and rule changes. One of the ones that probably are most common or familiar to the audience would be the change in the kickoff location in the NFL and the NCAA. That's from a combination of video analysis in conjunction with some of the head impact biomechanics that we captured and our group was one of the groups that provided good data to inform that. We looked in that one study of special teams plays and compared them to offensive and defense plays and special teams they were three times more likely of suffering a severe impact than in the traditional offensive and defensive play. We also looked on video at closing distance. We wanted to know the striking player and the player struck I they traveled more than ten combined yards before that collision, we categorize that as a long closing distance and anything less than that was short. We were four-and-a-half times more likely of suffering a severe impact in a long closing scenario than we were in a short closing.

In combination, special teams plays are worse the other two types of plays and long closing distance plays are worse than short closing distance plays so you can imagine that special teams plays had a long closing distance like a kickoff or a kickoff return would probably be the highest risk of a severe impact. The NFL took those data and the NCAA took those data and moved the kickoff line up and what we saw was a 33% reduction in the amount of kickoff returns essentially attempted if you will or attempted to run back.

After the initial salt in the wound of you're killing football and you're making it less exciting what we also found was a 42% reduction in the number of concussions on kickoff return plays in the NFL and the same number of points scored on kickoff returns. It's not that we had less scoring it's just athletes were being smarter with the opportunities they exploited to essentially score the same number of points but then they were more cautious in their decision of what opportunities to exploit. We found a reduction and that's probably the most obvious rule change that has emerged in the last few years and we hope that there will be many more to come.

Scott Livingston: Great. Thank you very much for that in depth answer. The next question that came in from our virtual audience is, can either of you comment a little bit more in depth on the effective trauma to the center of the head in close proximity of time? I think that individual asking is relative to some of that head impact data you reported being I believe it was among the ice hockey players in that study, most of the impacts were on the top of the head. Has there been any data if repeated impacts in close proximity among the hockey players increases their risk of injury, of concussion specifically.

Jason Mihalik: Sure, I'll expand the question if it's okay with you, Dr. Livingston to include all sports that we studied. That's one of the theories. We'll still trying to figure out why a 100G linear acceleration collision causes injury in one athlete and not another. Scratching our heads even harder, we're wondering why a 100G impact doesn't cause injury in one athlete and a 60G impact later that game does in the same player. One of the ideas there is it may be less about the area of the head and more the proximity of time of those collisions.

I grew up in an area of the Nintendo entertainment system where we had Mike Tyson's punch out. You would hit your opponent and there would be this little threshold bar that would go lower, lower, lower and eventually that person would be injured and you would with the bout. Maybe there is some truth to that from the standpoint of head trauma where early on in a session you can experience those big collisions and be okay but as the scenario wears on and you sustain multiple head impacts maybe your resiliency or your threshold for injury drops. Again, we don't have the answers there but it's certainly a very important question that I know we are starting to look at with the data that we have and that other very respected research centers are as well.

Scott Livingston: The next question shifts gears more towards the educational side of injury prevention and the question is, in addition to the CDC's Heads Up materials which I'm sure many participating in the webinar are familiar with, are there any other recommendations that either of you have for awareness materials, instructional materials specifically for coaches in addition to CDC's current tools?

Erin Wasserman: The CDC Heads Up tools are by far the gold standard of tools for coaches and probably are the best. For football there are a few other opportunities as USA Football has Heads Up instructional videos that can be as well as players and coaches. Most of the laws that have been passed across the country also have information on specific educational materials that are mandated to be provided to coaches and players and parents in the schools.

Jason Mihalik: Specific to ice hockey, USA Hockey is one of the ... I should say ice hockey in general is one of the few sports where there's actual required coaching education. If you're a hockey venue, you cannot coach a hockey team unless you are a certified USA Hockey coach. The material and the curriculum they put together actually addresses head injury and sports injury for the function of what you might see as a coach. If you're in ice hockey and you've gone through the USA Hockey coaching instruction, you should have also been exposed to perhaps some more sport specific implications for concussion.

Scott Livingston: That's great information for those who are coaching or otherwise involved in youth ice hockey. The next question deals with recovery time. Are either of you aware of any research that's been done looking at average recovery times for youth ice hockey players or hockey players in general across the different levels of competition either on recovery for return to play but also the impact of recovery on return to academics?

Erin Wasserman: There's been some limited research on recovery time in hockey. There's been much more in the football setting but there have been a couple of studies that have recently come out. I just actually did a study in the NCAA looking across all sports on return to play time and time for symptom resolution. That information is about 25% of athletes are returning to play in less than a week. Now with standards in return to play protocols, the NCAA has regulations that athletes must gradually return to play increasing exertion and a lot of those protocols require five days and that's after symptom resolution. We've done a really great job of improving return to play but I agree that return to learn rarely happens that it's studied is something that I have a particular interest in actually. Until we get to the professional level, almost all of these athletes are students first and athletes second.

The next stage is we really need to find out when the athletes are going back to school, what kind of services they're receiving, what kind of problems they're having. This is something that really hasn't been studies yet. We know that in some settings up to 50% of athletes would say that really need help when they get back to school but there haven't been any regulations set forth on what the standard protocols are to do that. That's something that the future of concussion research really needs to look at.

Scott Livingston: Thank you very much for that. Next question I believe is more primarily for Dr. Mihalik because you had touched on some of the football helmet design issues. Have there been any advances in ice hockey helmet design for any level of play that have been beneficial at decreasing the risks of discussions?

Jason Mihalik: I think the helmet industry should actually be commended. This is a very complex problem. There are a lot of people that have forgotten more about concussion than I'll ever know that have studied this problem for a very long time and we don't have the answers. This is very complex and they're trying to I think genuinely do the best that they can. No one wants to produce a product that they know won't work or won't keep someone safe, there's no reason to do that. I think there have been a number of advancements in material properties. Again, no has discovered unobtanium yet so we're not quite there. There is caution. Helmet manufacturers recognize this is a very hot topic. They're trying to beat each other to the punch if you will to put a helmet out there that is the next concussion proof helmet. That helmet just does not exist.

There are a number of cases that the Federal Trade Commission has explored. There's one case where they went after Riddell for making claims about concussion prevention in football helmets. Industry Canada and the Competition Bureau there, essentially Canada's version of the Federal Trade Commission has cracked down on both Bauer and Reebok CCM for claims that they have made about their helmets in hockey, their more expensive ones that they've marketed to be concussion proof. In both instances the manufacturers had to pay considerable fines to the government and then actually participate in a commerce retraining program where retailers were provided correct information to make sure that the person at the sporting goods store wasn't

using the wrong sales pitch anymore. There are more expensive helmets. Immediately, I think the public thinks it must be a better helmet and those claims aren't supported and the government is actually going after those manufacturers.

That having been said, all of these helmets on the market meet a standard and that standard is to keep you alive and recoverable and they all do a really good job of that. I think at the end of the day you should feel safe that your child won't suffer a catastrophic injury while playing these sports but remember again that the helmet, regardless of which one you choose, won't necessarily prevent all concussion.

Scott Livingston: Great, thank you for that. A couple of related questions to that. Are either of you aware of any advances coming up in helmet design specifically for ice hockey.

Jason Mihalik: None that I think I'm at liberty to discuss.

Scott Livingston: I thought I had another related question to ... Not so much with the helmet design but this goes back to a little bit on the helmet telemetry systems and the head sensors. Has there been any research done either in your lab there at UNC Chapel Hill or elsewhere on the reliability of the head impact telemetry systems or similar software in measuring head impacts.

Jason Mihalik: Yeah, there have been a number of research efforts ongoing. Only a handful have been published and so there's additional work that's being done in the area. At the end of the day for us to use a device and say for this one particular impact there is some level of error. The question is, is 10% error okay? I personally think it is. Is 100% error okay? Probably not. We're trying to figure out which devices perform better than others in the field. When we look at impacts that occur over the course of the season, we have 1,000 impacts for a player in college football for example, I think the data we're getting from the sensors when we combine it over the time period give a pretty good picture of the proportion of impact to the top, to the side, front, back of the head with those numbers severe, moderate, and so forth.

As an individual impact indicator, there is some question to ability to accurately measure that but over the collective of a period of time, I think they do a pretty good job. Understand that there are inherent limitations to it. We're trying to measure something that is supposed to be measured in the center of gravity of the head. Obviously, we can't get there. We can't find an IRB that would approve the study. You won't find participants that want to participate in it. I think we're doing the best that we can short of the limitations of anatomy and the construct of what we can do, where we can place these sensors.

Scott Livingston: As a follow-up question to the helmet design, are there any standards for helmets in other winter sports besides ice hockey? Snowboarding, skiing, or are

those much less regulated than ice hockey helmet design standards and wearing standards?

Jason Mihalik: There are standards for virtually any kind of helmet. The issue with the standards is you need a governing body to adopt the standards. For example, there's the NOCSAE for football and lacrosse. It's only good because US Lacrosse says if you play lacrosse under a sanctioned lacrosse event, you have to wear a standard helmet. For football, the NFL says you have to wear a NOCSAE certified helmet. The NCAA, every football governing body makes that requirement. In ice hockey in the United States they require that your helmet meets a Hockey Equipment Certification Council or the HECC certification which uses an ASTM model. Again, if you're a kid playing hockey and you have that sticker, an official can say you're off, you're not playing hockey anymore today. There's that regulation because the governing bodies of those sports require you to wear helmets that meet a standard.

In snowboarding and skiing, there are helmets and there are standards for those types of sports but if you're doing it recreationally or you're not competing in a league that requires it, then there's little enforcement on your ability to buy that helmet or not. It's a little bit more wild west if you will with some of those sports. I'll pick on bull riding for example. There's a bull riding helmet and face mask standard but the helmets that we tested in that market all failed the standard because many of them just hockey helmets that are re-branded. They're designed to keep you alive and recoverable in ice hockey but in ice hockey you don't have a 2000-pound bull stomping on your head so it's a very different thing. Again, there's no requirement in a National Finals Rodeo and the rodeo circuits don't require you to wear a helmet and certainly don't require a certain level of standardization of those helmets.

Again, there are standards for virtually anything that's built and sold. It's incumbent upon either the consumer or the governing body that overseas it to adopt that standard as the one that they require.

Scott Livingston: Okay. Our next question deals with some of the military applications in specific reference toward the end of the presentation some of the information that you presented on the work with the special operations forces. Do you see a time in the future where all military members will be required to wear or use some type of monitor that would enable objective monitoring of these injuries similar to some of the work that you described from a sports environment? Do you foresee that at some point in time also having more applications in a military setting where that becomes a requirement?

Jason Mihalik: Who knows what will happen in the next four or five years. The issue that these sensors can't be used to identify injury. There's no known threshold. I mentioned some examples earlier, a 100G hit doesn't cause an injury, a 60G hit does. If you're using an 80G threshold, you're going to have a lot of false positives and false negatives. Right now when you look at head impact indicators, those that light up, flash, buzz, beep, whatever their positive

predictive values, their ability to identify an injury that has occurred when it triggers as a positive event is less than 0.4%. For 1,000 incidents of positive flashes on this device, we're finding only four injuries are actually being diagnosed from that.

We're still far away from these indicators being clinically viable and only until that point would I think the military want to consider them for widespread use. Obviously, if the military were to adopt, we're looking at mass production of these devices. There would quality check processes that would have to be in place. The cost would hopefully be driven far lower than they are now. We think we're still many years away. I think certain groups within the military are using them. Another group we're working with acknowledges that it's pilot testing. They want to collect information to better understand what's going out there. One, to see if this is viable in the field and in training environment but then also to see if it's something even worth pursuing in the future.

Scott Livingston: We're close to the end of our questions that have come in. We just have two more. Are neck strengthening exercises recommended for use or even high school or older levels of play for ice hockey players? Is there any evidence that neck strengthening helps increase the risk of concussions among this particular sport?

Jason Mihalik: We did a study with our youth hockey cohort where we measured static strength. We looked at flexors, anterolateral flexors, anterolateral extensors, and so forth and essentially categorized them as strong, moderate, or weak relative to the group we tested. Those weak individuals could still very well be strong compared to other cohorts. We did find that that categorization of our stronger, moderate, and our weaker players affected in any way the head impact biomechanics. Hockey players in our study that had stronger necks relative to those in the weak category didn't have any less severe impacts than their weaker cohort.

That having been said, it was a static measure that we chose clinically on the treatment table before practice and before the start of the season. There's no way for us to measure the toneness or the extent of muscle contraction activity during actual play. We could estimate anticipation based on video review which is what we've done in the past but just because you see it doesn't mean you fire your neck muscles. There's a whole slew of issues that go with neck strengthening exercises that I think we need to be cautious. It's not the only solution. That having been said, being a generally strong individual minimizes your risk of many other injuries beyond just that of concussion. I think neck strengthening exercises should be part of a global and a comprehensive strengthening program that these athletes who participating in a sport should include in addition to other strengthening that address other areas of life.

Scott Livingston: Our last question, we saved probably the most controversial question for last. Do you think that it's possible to change the culture of ice hockey in which rough play is the norm since you described that that could definitely be one of

the leading mechanisms of head injuries and concussions in this particular winter sport?

Jason Mihalik: That's a pretty loaded question and you're asking a Canadian here. At the end of the day I think we can change rules to enhance player safety. One of those rules is changing the age of body checking. There was a lot of resistance to it in Canada but now they've implemented that as well. The NHL has implemented rules to strictly enforce intentional head contact. Most junior leagues, I think all of them to be honest, have eliminated fighting so there's another big rule that is trying to change the culture at that level. If you can't fight, you tend to recruit athletes that don't have to fight or don't have to enforce in that they're skilled technical players. As we kind of build that into the grass roots level and these players are getting drafted, fighting will become far less frequent at the professional level than what we're seeing now.

Interestingly, fighting really only accounts for less 3-4% of the concussions that are occurring at the National Hockey League level. Fighting is one of these things that is there and we want to get rid of it. I personally don't think there's a lot of room for it in the sport but it is not the leading cause of concussion in competitive levels where fighting is still allowed. Marcot did a study back in the early '80s called Fair Play where they actually awarded teams points towards they standings based on how disciplined they were. A team that did not, I forget the exact number so I may stand corrected later if someone finds the publication, I think if you did not exceed seven penalties in a game and you did not sustain a major penalty, in other words a five-minute penalty or greater, during the course of a game then you were awarded an extra point.

When you looked at the standings, those points factored into some teams that were overly aggressive and overly rough if you will not making the playoffs because they lost a lot of those fair play points and a lot of those other teams were able to recruit over the course of the season. It had pretty success and it stuck in some areas. I think there has been a resurgence of that philosophy now so it would be interesting to see if there are ways that we can change a point or a reward system for those teams that play within the confines of the rules to then further penalize the success of those teams that don't respect the rules or that play too rough.

Scott Livingston: Okay, thank you very much. At this time, we'd like to encourage participants to please visit the website, dcoe.dds.pesg.com to complete the online CE evaluation and to download or print your continuing education certificate or certificate of attendance, whichever is required for your professional licensure certification. The online continuing education evaluation will be open through Thursday, February 25. To help us improve future webinars, we encourage participants to complete the feedback tool that can be opened in a separate browser on your computer. To access the presentation and resources list for this webinar, you may download them from the files pod on the screen or at the DVBIC website, dvbic.dcoe.mil/online-education.

An audio recording and edited transcript of the closed captioning will be posted to that link in approximately one week. The chat function will remain open for an additional ten minutes after the conclusion of this webinar to permit our attendees to continue to network with one another. The next DCoE psychological health webinar topic, literature review on resilience in the military is scheduled for the 25th of February from 1:00-2:30 pm that's eastern time. The next Defense Center of Excellence traumatic brain injury webinar topic, management of sleep disturbances following concussion is scheduled for March 10, the same time 1:00-2:30 pm eastern time. Thank you again to all of our participants for attending and we hope you have a great day.

Operator: Thank you for your participation. That does conclude today's conference. You may disconnect at this time.