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

October 9, 2014, 1-2:30 p.m. (EDT)

“Gender Issues and Sport-related Concussion”

Welcome and thank you for standing by. At this time, all participants are in a listen-only mode during the duration of today's call. This call is being recorded. If you have any objections, you may disconnect at this time. I would now like to turn our meeting over to our host, Dr. Donald Marion. Dr. Marion, you may begin.

Thank you, ma'am. Good afternoon everyone and thank you all for joining us today for this DCoE traumatic brain injury October webinar entitled, "Gender Issues and Sports-Related Concussion," I think a very timely issue given the nature of sports-related concussion issues in the NFL and elsewhere these days. My name is Don Marion. I'm a clinical affairs senior advisor, providing contract support for the Defense and Veterans Brain Injury Center, or DVBIC. I'll be your moderator for today's webinar.

Before we begin, let us review some webinar details. If you experience technical difficulties, please visit dcoe.mil/webinars to access troubleshooting tips. Please feel free to identify yourself to other attendees via the chat box but refrain from marketing for your organization or your product. Today's presentation references and resources are available from the download files box on your screen and will be archived in the online education section of the DVBIC website. If you preregistered for this webinar and want to obtain continuing education certificates or credits, or a certificate of attendance, you must complete the online CE post-test and evaluation. It's very important. After the webinar, please visit continuing education -- one word -- .-dcri.mil.edu to complete the online CE post-test and evaluation, and download your CE certificate or certificate of attendance, whichever of those you require.

The Duke Medicine website online CE post-test and evaluation will be open through Thursday, October 16th, 2014, until 11:59 p.m., or midnight, and that's Eastern Daylight -- Eastern Standard Time; right?

Yes.

Daylight time. Throughout the webinar, you are welcome to submit technical or content-related questions via the question-and-answer pod or 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.

So I'll now move on to today's webinar, "Gender Issues and Sports-Related Concussions." The Centers for Disease Control and Prevention reports that approximately 1.6 to 3.8 million sports

and recreational concussions occur annually in the United States. Epidemiologic studies conducted to understand sex differences between female and male athletes with respect to sports injury incidence and prevalence have shown that female athletes at both the collegiate and high school levels are at a greater risk for incurring a concussion. In addition, females have been found to report slightly longer concussion symptoms and cognitive impairment.

The empirical findings on sex differences and sports-related concussion warrant clinical considerations when assessing concussion among male and female athletes. So at the conclusion of this webinar, participants will be able to, one, describe current research regarding gender issues and sports-related concussion; two, identify sports at high risk for concussion at both the high school and collegiate level; three, articulate gender differences in post-concussion symptoms and concussion outcomes; and, four, discuss the importance of concussion management for both male and female athletes.

So we're fortunate today to have a national expert in this area, Dr. Tracey Covassin, who is an associate professor and certified athletic trainer in the Departments of Kinesiology and Intercollegiate Athletics at Michigan State University. Dr. Covassin has served on the Institute of Medicine, a National Research Council Sport-Related Concussion in Youth Committee, which released sports-related concussions in youth, improving the signs, changing the culture, in October of 2013. It's a red, white, and blue book, actually, chocked full of important details regarding sports-related concussions. She directs a multisite high school and college sports concussion outreach program in the mid-Michigan area and has received funding as a principal investigator from external sources, including the National Operating Committee of Standards for Athletic Equipment, or NOCSAE; National Athletic Trainers Association Research and Education Foundation; NFL charities; and the Centers for Disease Control and Prevention. So with that said, thank you, Dr. Covassin, for joining us today and I'll turn it over to you.

All right, thank you, Dr. Marion for that nice introduction. As Dr. Marion said, my name is Tracey Covassin, and I work at Michigan State University as an athletic trainer through the Department of Intercollegiate Athletics and the Department of Kinesiology as a researcher and program director for our undergraduate Athletic Training Education Program.

Today I'm going to talk about gender issues and sport-related concussion. So I currently do not have anything to disclose, and the views expressed in this presentation are of my own views. They do not reflect the official policy of the Defense Department, United States Government, or Michigan State University. I do not intend to discuss off-label or investigative unapproved use of commercial products or devices, and I do not have any relevant relationships to disclose.

So just a brief overview of what I'm going to talk about today in my presentation. I'm going to go over epidemiology, a sport-related concussion, from both the high school and the collegiate level. I'm then going to talk about gender differences in concussion symptoms, and then gender differences in concussion outcomes, and then I'm going to talk briefly about management considerations for male and female athletes, and a little bit about changing the culture.

So, before we get started, I have two questions for you for our polling questions. So my first question is true or false, females are at a greater risk for concussion in sex-comparable sports? I will give you a couple seconds to answer that. Okay, so the results of that question, 75% of you said it was true and 25% of you said that was false. That is actually true. So we're going to talk a little bit about that today, but sex-comparable sports refers to your soccer, your basketball, your softball, baseball, and females are at greater risk for concussions when we look at those sex-comparable sports.

My second polling question, true or false, compared to females, males have more injuries to player-player contact than player-service contact or player-equipment contact, and this specifically relates to a concussion? So for this question we had pretty much the same answer. 74% of you believe that was true and 25% of you believe that is false. And the answer to that is actually true. So males tend to get their concussions due to player-player contact, and that would be typical in your football athletes or ice hockey athletes that would have player-to-player contact, whereas the majority of female sports are actually non-contact, so they would get their concussions with either equipment or hitting the surface.

So I'm going to start to discuss a little bit about epidemiology of sport-related concussion. Well as Dr. Marion indicated, the CDC estimates that there are approximately 1.6 to 3.8 million sport and recreational concussions in the United States each year, and research has recently shown that females tend to be at a greater risk and have a higher incidence for sport-related concussions than males in comparable sports.

When we consider U.S. Service Members, there was nearly 23,000 concussions or mild traumatic brain injuries that were diagnosed in 2013. And this represents about 84% of all TBIs in the population. So about 85% of all TBIs in U.S. service members are actually ether a concussion or a mild TBI. And although we typically think of a TBI as an injury from the wars in Afghanistan and Iraq, more than 80% of these TBIs in the military actually do not occur in the deployed setting. The majority of these TBIs occur due to motor vehicle accidents, either their own personal private owned vehicle or military vehicles, but they also occur to service members during falls, sports and recreational activities, and military training.

So even though my presentation today is really going to focus on sport-related concussion, primarily at the high school and collegiate level, there is no reason to suspect that service members between the ages of 18 and 22 who either play intramural sports or service academy sports have any different concussion risk than non-service member athletes, so compared to our collegiate athletes.

But what we do know is, as a result of this increase in concussions, that these concussions were increased in cadets, the military is trying to decrease these cadet concussions and West Point has actually substituted flag football for its intramural football and has eliminated rugby altogether. So they are actually trying to make some changes to actually decrease the number of concussions that are occurring in service members in sporting activities.

So I'm going to talk a little bit about the NCAA Injury Surveillance Program. Originally, it was the NCAA that collected injury surveillance data, and they have been collecting this for over 25 years, and recently, over the past couple of years, Data List Research Center has actually taken over the NCAA Injury Surveillance Program, but they are actually sponsored by the NCAA. They just went to an external source for actually managing and collecting this NCAA Injury Surveillance Program data.

So the NCAA has a reportable injury as defined as an injury that occurs as a result of participation in an organized intercollegiate practice or competition. That injury, or in this case, the concussion, must require medical attention, either by the team certified athletic trainer or team physician, and must be restricted from participation of one or more days beyond the day of injury.

This slide, which is slide 24, represents NCAA concussion rates per 10,000 athlete exposures. Now I'm first going to define what a concussion rate is. It is the total number of concussions divided by the total number of athlete exposures, and this slide represents that concussion rate per 10,000 athlete exposures.

So an example of how we would calculate the 6.0 concussion for football, if we took an NCAA team that had a hundred football athletes and hypothetically they practice five days in the week, we would then take a hundred athletes times the five days they practice, and that would be 500 athlete exposures. But now we're going to take 20 NCAA teams who also had a hundred athletes and practiced five days in that week. That would represent 10,000 athlete exposures. So out of those 20 teams that practiced during those five days, six athletes would have incurred a concussion, so that's how they would get the 6.0 concussion injury rate for the football teams.

But if we look at this slide here, and we look at the NCAA concussion rate, this is a recent injury rate that was actually given to me through Data List Center from 2008 to 2012/13. And you will notice underneath women's sports that women's ice hockey, women's soccer, and women's lacrosse all have a slightly higher injury rate than collegiate football athletes. If we then compare women's sports to men's sports -- we will look at women's ice hockey -- and females have an injury rate for concussions at 7.0, compared to men's ice hockey at 6.0. You will notice that women's soccer is at 6.7, compared to men's soccer at 4.2. Lacrosse is fairly equal between males and females, but basketball is also higher for women, at 4.8, compared to men at 3.4. And then finally, if you look at the bottom, softball is at 2.3 compared to baseball at 1.1.

So we know that the NCAA injury surveillance program has actually shown that females in those sex-comparable sports of soccer, basketball, and softball have a higher risk and a higher injury rate compared to males in the same particular sport, but the one thing that is interesting is women's ice hockey, women's soccer, women's lacrosse have a slightly higher injury rate than your collegiate football athletes.

Now I'm going to turn our attention a little bit to high schools, so your adolescents age 13 to 18 years old. So a study was done by Lincoln and Colleagues that was published in the American Journal of Sports Medicine in 2011, and they examined the incidence and risk of concussion in 12 high school sports. They looked at a ten-year period, from 1997 to 1998, all the way through to 2007/2008, and they had 25 high schools in the Fairfax County, Virginia, public school district. They used certified athletic trainers as their data recorders, and they used SIMs, which is the Sports Injury Management System. SIMs is an electronic system that's actually used by athletic trainers, where we input injuries and treatment plans into the this electronic system, so they use that to keep tract of athletes who had concussions.

This study defined a concussion as an event that occurred during an official game or practice, was brought to the attention of an athletic trainer and then determined to be a concussion by that athletic trainer. In this particular study, each concussed athlete had a clinical exam, symptom checklist. They used the Standardized Assessment of Concussion, which is otherwise known as "SAC," and they also used the Immediate Post-Assessment and Cognitive Test, which is also known as "ImPACT," and that's a computerized neurocognitive test that is given to athletes.

Slide 27, what this study actually found was that 2,651 high school athletes had sustained a concussion over the ten-year period. Just a little bit about the next bullet point, football did have the highest injury rate of concussion. The .60, the way they the study reported it was per 1,000 athlete exposures, so if we considered that per 10,000 athlete exposures, which is what the

NCAA reports it in, that football concussion injury rate would actually be at a 6.0, which was the same as the NCAA.

But in this study they really wanted to examine differences between males and females, again, in the sex-comparable sports. And what this study found was that female soccer players were at a 2.1 times greater risk for a concussion compared to male soccer players. They also found softball to be almost at a two times greater risk for a concussion compared to baseball. And as well as, girls basketball had a 1.7 times greater risk compared to a concussion -- compared to baseball athletes. The one sport that they did find boys having a higher injury rate was lacrosse, and that would have been -- using a 10,000 athlete exposure -- would have been 3.0, compared to girls at 2.0.

Now these are the actual injury rates for this study. As you can see, again, football was at 6.0. But you can see how much higher women's soccer was at the high school level at 3.5, compared to boys soccer at 1.7. Basketball, again, for girls at 1.6, compared to boys at 1.0, and then softball at 1.1, compared to baseball at .6.

Now slide 29, this slide represents the percent increase of concussions over the ten-year period for high school athletes. So you can see the highest percent increase was actually in wrestlers. So over the ten-year period, from 1997/98 to 2007/2008, wrestlers had increased their concussions by 27%. But if you look over at the girls' sports, you will notice that cheerleading had increased by 26%, and that is something that we're really finding, is that cheerleaders are on the rise from concussions.

But then if you look at the other girls' sports, every single other girls' sports had increased by either equal or higher than the boys' sports on the left-hand side. So basketball had increased by 24% for girls, compared to 17% for boys. Softball increased by 23%, compared to baseball at 14%, and soccer increased by 17% in girls, compared to 13% in the boys. If you do notice, you will see that football only increased by 8%, and what that pretty much tells us is that football is a sport that obviously has a lot of concussions, but it has stayed fairly equal over the ten-year period at the high school level, and it's only increased by 8%. But the biggest sports, that if we are working with high school athletes or have high-school-age children that we need to consider that are on an increased risk for concussion, it would be your wrestlers in boys and definitely your cheerleaders in girls.

On slide 30, this is another study that was done by Marar and Colleagues that was also published in the American Journal of Sports Medicine, and this was another study that looked at high school athletes. This study looked and used the reporting information online, which is the RIO Injury Surveillance Program. This electronic medical system, again, the RIO Injury Surveillance was developed by Dr. Don Comstock, and it primarily is used for high school. Again, athletic trainers didn't put the information into the RIO System. So what they did was they looked at the data that they collected from RIO from 2008 to 2010 across 20 sports. And out of all the injuries that these high school athletes throughout the United States had sustained, 13% of all injuries were concussions. And we think about that, greater than one out of ten injury was a concussion for high school athletes. And, again, when we look at risk between males and females, you will notice, again, that softball has over a three-times greater increase risk for a concussion compared to baseball. Girls soccer had over two times greater risk for a concussion compared to boys soccer, and girls basketball had just slightly over a one-times greater risk, at 1.3, compared to boys basketball.

Overall, when they looked at all 20 sports, they found that girls sports had a 1.7 times greater risk for a concussion compared to boys. So what this is telling us from an epidemiological perspective is, definitely, when we are looking at sex-comparable sports, females are at a higher risk for incurring a concussion compared to male athletes. We even know that there are some sports that actually have a higher increased risk for a concussion than your typical collegiate football athlete.

There are two, primarily, mechanisms that occur of how these individuals are sustaining their concussions. We know that the majority of female athletes participate in non-collision or non-contact sports. Even though the sport has been deemed a non-contact sport, we definitely know that contact occurs, particularly in women's ice hockey and basketball and soccer. There's always going to be some contact, even though it is not allowed. We know that female athletes tend to incur their concussions due to player-surface contact, so them hitting the ground, or player-equipment contact, them being struck by a stick or struck by a ball, and they get more of these concussions with this mechanism compared to males. We know that males tend to incur their concussions due to player-player contact, compared to female athletes. And, again, this is your typical football athletes, ice hockey athletes, lacrosse athletes, all of which is a contact or collision sport, and they definitely, then, would have their concussions due to player-player contact.

So some potential reasons why females may be at a greater risk for a concussion, there was a study that was done out of Temple University by Tierney and Colleagues in 2005, and they looked at differences between males and females in regards to their strength and their neck girth. And what this study found was that females had 50% less isometric neck strength, but they also have 23% less neck girth. And when you look at head and neck segments, it's 43% less in females compared to males.

But what the study also found that was that females had 50% greater head neck peak acceleration. So what this is telling us is that females tend to have greater acceleration at the head and neck, which means they're rotating their head faster. And we think that this is what is predisposing females to having more concussions than males.

When we consider Newton's Law of Acceleration, we know that as the mass of an object increases the acceleration of the object is going to decrease. So if we consider this in the context of Dr. Tierney's study, we know that females have less mass; therefore, they're going to have greater acceleration. And this acceleration, particularly in soccer athletes, is occurring at the head and neck. So this greater acceleration is a potential reason why we think that females are at a greater risk for a concussion than males.

Another potential reason for soccer athletes is we know that female soccer athletes tend to have a larger ball to head size ratio than males, and this may also predispose them to having a greater number of concussions. And the one thing that -- we really don't have any research to back this statement up, but some clinicians have been reporting that there may possibly be differences between males and females due to their reporting. So it may be that females tend to report their concussions at a higher rate compared to male athletes, but other than anecdotal and clinical evidence there really hasn't been research to support that males have lower reporting of their conclusions than females tend to report their concussions more. But that is something that I think we do need to consider, is there a possibility that that there is a difference in reporting.

I'm now going to turn your attention to gender differences and concussion symptoms and outcomes. So on slide 37, I'm now going to talk a little bit about differences between males and females, and what they report for their concussion symptoms. So Colvin and Colleagues did a study in 2008, and they actually specifically studied soccer athletes, and they looked at high school and college soccer athletes who had incurred a concussion. And what they found was that after a concussion, female athletes had demonstrated more symptoms compared to male athletes. What they specifically found was that they demonstrated more total concussion symptoms. So, typically, there is about 22 concussion symptoms that is these athletes can report, and overall, when they combined all 22 concussion symptoms, females had demonstrated more symptoms than male athletes. They also looked at individual differences in symptoms, and they found that females had indicated that they had a greater severity in their headache and had demonstrated more headache symptoms compared to male athletes.

In another study that was done by Broshek and Colleagues, she also looked at athletes and pre and post tests, you know, following their concussion, and what she also found was that after males and females had incurred a concussion, it was the female athletes, again, who had reported more concussion symptoms than male athletes, and specifically in this study, they found that female athletes reported poor concentration. They had more lightheadedness. They reported increased fatigue, and they were seeing stars more frequently than male concussed athletes.

And then finally, in a study that was published by Preiss-Farzanegan in 2009, this study actually looked at individual athletes who had incurred a sport MTBI and that had actually gone to the emergency room for their MTBI. So they looked at differences between males and females for individuals that went to the emergency room with their concussion. So they were obviously examined in the emergency room, and then these individuals were contacted three months later and they were administered the Rivermead's Post-Concussion Symptom Questionnaire. And what they also found was that three months later, females were at a greater risk of post-concussion symptoms compared to male athletes, and specifically, again, they looked at individual symptoms, and females had elevated risk for headache, dizziness, fatigue, irritability, and concentration. So some similar symptoms that these other studies had reported; headache, the fatigue, the concentration issues, they were more prominent in females compared to males.

So, on Slide 41, I'm now going to turn your attention a little bit to gender differences and concussion outcomes, so now looking at what are some of the neurocognitive or postural stability balance test scores and how are athletes affected after their concussion in reference to males and females. Well, one of the very first studies that looked at gender differences and concussion in athletes was actually done by Broshek and Colleagues in 2005, and they had administered the Concussion Resolution Index, and the CRI is a computerized neurocognitive test that is developed by HeadMinder, and it is a concussion test that is primarily administered to athletes for comparison, to get a baseline, and then to compare them to their post-test concussion scores.

So these high school and collegiate athletes were administered the CRI, and they did not find any gender differences at baseline, so they actually didn't find differences between males and female on their baseline test scores, but what they did find was that after athletes had incurred a concussion, they found that it was the female athletes that had a greater cognitive decline following their concussion compared in males. So, in this particular study females actually had greater cognitive decline.

So then what they wanted to do was they wanted to look at a Reliable Change Index or the RCI. And RCI is more of a clinical significance rather than the statistical significance that you may get, where the numbers really don't really mean anything other than statistically they appear significant. So they looked at RCIs and from the clinical standpoint, they actually found that 57% of the females in their study were clinically impaired. And this compared to 33% of male athletes who were impaired.

On slide 42 what the researchers then wanted to do was they were not certain if it was maybe has to do with males wearing helmets in your typical football, ice hockey, lacrosse sports, and males not wearing helmets, so your basketball, soccer injuries. So they then wanted to separate this group of concussed athletes into the female athletes who none of them wore helmets, and then they wanted to split the male athletes from those who wore helmets and those who did not wear helmets. And they wanted to see, again, were there differences on their cognitive performance after their concussion compared to their baseline.

So what they found now, was they still found that females demonstrated significantly slower response speeds on complex reaction time, processing speed, and simple reaction time, compared to males who did not wear helmets. Females also demonstrated slower response speed on their simple reaction times and more symptoms compared to male athletes who wore helmets. So it didn't matter if the females were compared to the athletes with helmets or without helmets, they still had more concussion symptoms, and they still had a slower reaction time compared to male athletes.

So, overall, again, they looked at the Reliable Change Index, and just like before, because it was the same group, 57% of females who did not wear helmets, which was their population, were clinically impaired. They then again separated out the helmet group from the non-helmet group for males, and 34% of males who wore helmets were clinically impaired, but that number dipped slightly lower, to 27% in males who did not wear helmets. So, overall, the study found that athletes were cognitively impaired 1.7 times greater than male athletes.

So in another study that was done by Colvin and Colleagues, he specifically just wanted to look at soccer athletes. So this is something that I'll also talk about, where we did a study just with soccer athletes. It is a sport that is very similar between males and females in terms of the environment that it's played in and the rules that it's played in, so it is a sport that you can almost get a better comparison. If we think about ice hockey or lacrosse, males are allowed to body check or they're allowed to make contact, whereas female ice hockey or lacrosse players are not. So soccer athletes is definitely a sport where we feel like the environment is going to be similar.

In this study they had actually administered ImPACT, which is a computerized neurocognitive test program that is administered to high school collegiate, and professional athletes. And in this study they had 234 concussed athletes, and this study also had similar findings to the Broshek study. What they found was that their female concussed soccer players had demonstrated slower reaction times compared to male soccer athletes, so this was also another study that found females had a slower reaction time following their concussion compared to male athletes.

So, recently, we had published a study in 2012, in the American Journal of Sports Medicine, and this was actually a NOCSAE-funded study, and we wanted to look at sex and age differences in post-concussion symptoms, neurocognitive performance, and postural stability following concussion. We had hypothesized, based upon previous research, that high school athletes and female athletes would have greater or more concussion symptoms, they would have worse

neurocognitive test scores, and their postural stability or their balance would actually be worse than male athletes.

So, in this study, we actually had a multi-site study. We had high schools and colleges from California, from Michigan, from Louisiana, and from Tennessee. We tried to get more of a national representative sample for this study. We had 296 athletes who had incurred a concussion, and after we placed exclusionary criteria on these athletes, 222 athletes we used for the study.

So, for our study, we actually administered ImPACT, the computerized test program, at baseline, and then on day 2, 7, and 14 post-concussion. We also administered the Balance Error Scoring System, which is a test of their balance or their postural stability. It's more of a clinical test that is used primarily with athletic trainers in a field setting. So we had administered the BESS at day one, two, and three post-concussion. The Bess tends to be reliable and accurate up to three days post-concussion, so we only did it up to three days. With all of our studies, we actually have the sports medicine staff at each institution determine whether or not the athlete is ready to go back to play.

So the results of our study, when we looked at the BESS or the postural stability of these individuals, we actually found an interaction for sex and age. We actually found high school males scored slightly worse than high school females. We also found that college females scored slightly worse than male collegiate athletes. With this one, you know, we found some balance issues, but we did find it in differences between the high school athletes and the males.

When we specifically, then, looked at the actual concussion symptoms or the female athletes performing worse than male athletes on the cognitive performance, what we again found was that females reported more symptoms than males, and we also found that female athletes performed worse than male athletes on visual memory. So we also found some differences between males and females on the study.

In another study that we actually just recently had published in the American Journal of Sports Medicine last year, in 2013, so on slide 50, this slide, we really specifically, then, wanted to just look at soccer athletes. So we examined neurocognitive performance in male and female soccer athletes, and, again, we looked at concussion symptoms, as well as concussion cognitive test scores following their concussion. We didn't have that great of a sample size, so that definitely is a limitation, 39 males and 56 females, but it's definitely hard to get concussed subjects using just one sport. We did have a multi-sample site study that we used for this, but we did have almost a hundred athletes.

We did exclude athletes who had a learning disability, ADHD or ADD; a history of brain surgery; color blindness -- you actually can't do ImPACT if you're color blind or get accurate results -- and then any athlete who had a chronic history of migraine headaches. We were thinking that maybe one of the reasons why females tend to report more headaches might be because females, just within the general population, have a higher incidence of migraine headaches. So we actually did exclude those individuals who had chronic migraine headaches.

We had administered ImPACT at baseline in eight days post-concussion for this study, and we actually had partial support for sex differences between male and female concussed soccer athletes. So this one, we actually found the interaction between times and gender, so we found that female soccer athletes scored lower on their visual memory compared to male athletes at eight days post-concussion. So what we found in this study was that eight days following their

concussion, males had recovered on visual memory, where females were not only still impaired from baseline, but they were also still significantly impaired compared to male athletes eight days post-concussion. We also found that female concussed athletes presented a greater number of total full concussion symptoms compared to male athletes. So very similar findings, again, where we found that females had greater symptoms, as well as greater cognitive impairments, and the study specifically at the eight days post-concussion.

In another study that we published in 2010, we actually did not look at the concussed athletes from an acute standpoint. We wanted to actually look at the study from a retrospective standpoint, and we wanted to look at differences between males and females who had multiple concussions. So we specifically were trying to examine if there was a dose response between males and females on cognitive performance in athletes who had a history of concussions and who did not have a history of concussions. So we retrospectively, in this study, we had separated them into four groups. So in this study they were separated from athletes who did not have a history of concussion, an athlete who had one previous history of concussion, an athlete who had two previous concussions, or three or more previous concussions.

When we looked at the results for this study, we did find that females with a history of two, or three or more concussions actually performed better than males with a history of two, or three or more concussions on verbal memory. So in other words, what we found was that male athletes who had two or three previous concussions, so they were not actually concussed at the time that we administered the cognitive test, but we found that those male athletes had lower cognitive performance on verbal memory compared to female athletes.

We also found that female athletes who had three or more concussions performed better on visual memory. So if we kind take the flip side of that, male athletes with three or more concussion performed worse on visual memory. When we just looked at a group of all males and all females, so not separating them out from their dose response, so from zero, one, two, or three or more concussions, we found that males performed worse than females on processing speed and reaction times. But the one big finding that we had with this one was that males who had two or three previous concussions were actually scoring worse on verbal and visual memory compared to female athletes with the same number of previous concussions.

So a potential reason why we think these male athletes may be scoring lower on their cognitive performance after they've had all these concussions, there is a possibility that these individuals may have incurred a more severe concussion compared to female athletes. So even though we do not grade our concussions anymore to determine the severity, we can look at the amount of time that these individuals were not participating in their sport, so the amount of time from their concussion to when they actually returned to their sport. So it could have been that these male athletes had a more severe concussion, which may have resulted in them having decreased cognitive performance on verbal and visual memory.

It also could be that in this study we actually kind of had an overrepresentation of collision sports in football and ice hockey, which we cannot state this. There's nothing to back this up, other than me just stating it. But there is a possibility that the population of males, especially the ones where we have the abundance of football and ice hockey, they may have actually incurred other concussions, and that may have actually affected their cognitive performance. So they actually, instead of two concussions that they had reported, because we specifically asked them "How many were you diagnosed with by a physician". And we know that athletes, at times, do not report all their concussion symptoms. So maybe these male athletes, instead of only being diagnosed with two, maybe they had three, four, or five, because they didn't report two or three

concussions that they had. So that might have been the reason also why we had differences between males and females in previous concussions.

So what exactly could possibly account for differences in concussion symptoms, and account for differences in their cognitive performance following a concussion? There is this primarily female sex hormone, estrogen. We really are not sure exactly the role that estrogen plays in concussed athletes. There have been studies that have been done that have shown it to be detrimental and actually shown estrogen to be a neuro-protective effect in regards to concussed individuals. The majority of research that is done on sex hormones is actually done in animal models, so it's really difficult to take it and actually infer it from the animal models to the humans.

So Emerson did a study where they had administered estrogen, prior to the brain injury, to rats. And then they had hit their heads and actually induced a concussion. And they actually found that estrogen protected the male rats, but exacerbated the symptoms in the female rats. So in this particular study, they found that estrogen was detrimental to female rats who were concussed. When we consider progesterone, it may act as a neuro-protective effect in animals, as it was found to decrease cerebral edema or down regulate the inflammatory cascade response to neuro trauma. So, again, there is conflicting research right now of whether or not estrogen and progesterone actually helps these individuals or actually acts as a detrimental effect.

There's also a potential reason why females and males have greater symptoms, and females have greater cognitive impairment. Maybe because, just in the regular female individuals, they have a great rate of cerebral blood flow. They also have a greater basal rate of glucose metabolism. And we know when an individual gets a concussion it's exacerbating the metabolic cascade. And because now the metabolic cascade has occurred in the concussed athlete, we know that after a concussion there's decrease in blood flow. Well, females start with a greater rate of blood flow and now they have a decrease in cerebral blood flow, they actually may have greater rate of decrease in cerebral blood flow and an increase in glycemic demand? So this may actually affect female athletes differently than males. We know that they are taking longer to recover and have neurocognitive impairment compared to male athletes.

On slide 59, again, you know, this really is not backed up through research, but it has been said in some NFL players that males tend to play through their pain and hide their symptoms. So we do know from a clinical standpoint, we have seen the males that play through pain and hide their symptoms, and this is not to say that females don't do that, because we definitely have female athletes who also hide their symptoms and don't report them. But it may be that there's more males who try to hide their symptoms. We also know that, again, just females may report their concussions more frequently than males, and we know when we look at other literature that females tend to be more concerned about the effects of their future health compared to male athletes. So they actually may be concerned about their future health, where maybe your collegiate football player who has aspirations to go to the NFL, at that point, obviously we know they're young, they may not actually consider their future health, and all they're thinking about at this point is going to the NFL.

So, what we also do know is that females have less opportunity for professional careers than male athletes. We just know that males can go to the NBA, NHL, major league baseball, and the NFL. They have an opportunity to play professionally and to make really good money playing professionally. And because of that, they may actually hide their concussions. We do know, or at least from our standpoint working at Michigan State University, that when they go to the

combines for the NFL, that they look at their medical history very closely. Obviously any athlete who has three or four concussions that are in their files, some of these teams are going to take a closer look at whether or not they actually want to draft them. So, because of that, they may actually hide their symptoms more frequently than females. And we also know that males and females could be affected differently when told they actually cannot participate due to their concussion.

So, on slide 61, I'm going to kind of turn your attention a little bit to management considerations. We do know now than when we manage a concussed athlete, regardless of if they are a male or a female athlete, if they are high school, a collegiate athlete, a U.S. service member, we need to use a multifaceted approach to managing the concussed athlete. And we need to look at each individual or U.S. service member from an individual basis. But some of the things that we may want to consider when we are examining these individuals, we want to keep in the back of our minds that females tend to be at a greater risk for a concussion in soccer, basketball, softball, and cheerleading, so we need to just consider that when those athletes walk into a physician's office, that they may have actually incurred a concussion.

We also know that females may have more concussion symptoms. Again, they seem to report a headache more frequently than males, but we also need to keep in mind that we need to take a history of whether or not these females have a history of migraine headaches, because we know that females tend to have a greater incident of migraines in the general population compared to males. And then when we consider some cognitive performance, we know that females who are concussed may have slower reaction times. So, from a health care professional standpoint, we need to consider to look at their reaction time and also consider that we know that females will tend to report a slower reaction time compared to males.

When we do take a history of this athlete, we need to really take a good, detailed, history of previous concussions, both from service members and from the athlete perspective. So, when we take a detailed history, this is not all about football players. We need to take a detailed history of every single person, because at some point they probably played some type of sporting event or had some type of concussion that was due to a non-sporting event. We need to make sure that we don’t just ask these service members or these athletes "How many concussions have you had.” They're probably going to say one or two, or none. We need to not only get the number, but we need to ask some questions about their signs and symptoms of their concussions. We need to try to get an idea of the severity of these concussions that they actually had in the past.

We also need to ask some questions of whether or not they had a previous head, face, or neck injury. If we consider the basketball player who took an elbow to the face and that individual has an orbital blowout fracture, so we are now concerned about the eye, we are concerned about the fracture. But we may actually miss that coexisting concussion that occurred with that eye injury, so we need to also ask the athletes about these previous head, neck, and face injuries. Maybe they had incurred a concussion and they didn’t just realize it because we were concerned about the other injury.

We also know that, especially when we talk to young athletes or young service members, you know, our typical adolescent up to the 22, 23-year-old range, when we ask them, "Have you had a previous concussion," and they are your football player, they really sometimes only think about their football injuries and they don’t actually think back to maybe they got a concussion playing basketball or got a concussion playing soccer. So we want to make sure that we have probing questions about other sports that they may have had concussions, but we also want to

ask them about non-sport injuries. Did you ever fall off your skateboard? Did you ever fall off your bike? Did you ever -- were you ever in a car accident where you may have actually incurred a head injury?

So we want to make sure when we are managing these individuals, we have a very good detailed concussion history, and it doesn't just stop by asking them one question, have you had a previous concussion. So, we want to get a very good history.

On slide 63, we need to educate. We need to educate service members. We need to educate athletes, coaches. But we also need to educate health care providers. So, we still need to educate the pediatricians, the family physicians, the ER staff so that they know some differences between males and females so that they also know -- you know, definitely know the signs and symptoms but they also need to know that returning an athlete should be in a step-wise progression, that they shouldn't just return the athlete the next day. So education is very key to trying to change the culture of concussions, which is the last area that I'm going to talk about.

So, on slide 64, there was a study that was done by McCrea and Colleagues published in 2004. This study found that 44% of high school football players reported they did not want to leave the game as their reason for not reporting a concussion. So 44% of high school football players just didn't report their concussions because they didn't want to leave the football game. 66% of them just didn't even think their concussion was serious enough to warrant medical attention.

While we know this study was done ten years ago, and we know that when we consider all the media hype that has occurred, when we consider all the changes we have made in diagnosing and managing a concussion, it's in the news, it's on ESPN, on the "New York Times" all the time, one would think that this would change from ten years ago.

So, a study was published in 2013, and they looked at 2012 high school football players. And what they found in this survey was that the majority of high school football players had indicated it was okay to play with a concussion and that they were going to play through any injury to win a game, despite the fact that these high school football players were knowledgeable about the signs and symptoms of a concussion and they knew the dangers of playing with a concussion.

So, what this told us was that ten years later we now know that individuals have more knowledge about concussions, they know that they are dangerous if you play with a concussion, but they're not changing the culture. They are still going to continue to play through it. So, when I actually was privileged enough to sit on the IOM Committee on Sports-Related Concussion in Youth, we actually had an athlete come talk to us and give his perspective of what he went through with his concussion. So this individual, Chris Coyne, this is what he told us during his time that he spoke to us.

So, when he was in high school, his first concussion occurred when he hit his head on the high bar, jumping as a high school freshman athlete. So he told his athletic trainer, but he didn't really think too much about it. This was in spring, where football wasn't in season. This was as a freshman. He was trying to high jump. It didn't really matter to him that if he sat out a couple of weeks from it because it wasn't football. So, he had his first concussion when he was a freshman high school athlete.

But then he was actually privileged enough to go from his sophomore year to actually be able to play on the varsity team, and he was actually a starting tight end for his high school varsity

team. And he incurred a second concussion, and this was what he stated: "Right away I knew this was more severe than the first one because I couldn't walk straight and I couldn't remember plays from the huddle. But I decided to play through it because of the position I was in, and I didn't want to let the team down." He felt like what had happened earlier was their starting tight end for the varsity team went down with an injury, and he was called up to play, and he did not want to let his teammates down, so he didn't tell anyone.

However, for weeks he had headaches. He had insomnia. His grades actually suffered, but he remained quiet. He did not report his concussion. He said he was going to, but he wasn't going to report it until the last game of the season was over. He actually didn't make it until the last game of the season. He had his third concussion, as what we would like to say in the high school setting, kinds like to horse around in the locker room. Chris was doing that. So he was playing around with his teammates and he actually had incurred his third concussion. He lost consciousness in this concussion. So they actually took him over to the athletic training room to be evaluated. So he actually did not have a choice in this one to hide it because he lost consciousness and was brought over to the athletic training room.

At this point, he decided to tell his athletic trainer about the previous one and also told his mom about his other concussion. He did not play for the remainder of that season, but he did incur his fourth and a fifth concussion while playing high school sports. He was lucky enough to actually be recruited to Yale University. He was extremely smart and a good athlete, and he was playing for Yale University. During his freshman year at Yale University, this actually occurred during preseason, and he suffered his sixth concussion while doing a routine defensive end drill, and it was a helmet-to-helmet hit. So, at the time when he was hit, obviously a freshman just starting preseason, he considered keeping quiet again. But after a couple of days he changed his mind because -- he said this: "I would get up off the couch to get a Gatorade and then I wouldn't know why I was standing up." He then realized when classes started he would take notes but he couldn't remember what the lecturer had just said.

He ended up telling his team athletic trainer and team physician, and he ended up not playing. He eventually was medically disqualified. This was a freshman year preseason. This was August of his very first year at university. During his second semester at Yale University, so around six months later, he still had memory lapses, and now he was diagnosed with ADHD and had to take medication. So, six months later, he had some serious affects from this concussion. On page 68 -- sorry, slide 68, he was actually medically disqualified his freshman year in November. He had very good support from his family, very good support from his coaches, and very good support from the dean of his college who had given him academic accommodations for his concussion, and very good support from the majority of his teammates.

However, there were a few teammates on this team that didn't understand the invisible injury. They knew when that athlete went down with an ACL injury. They saw the athlete who had surgery. They could see the scar. They could see the immobilizer on his leg. They could see the crutches. But they couldn't see Chris' concussion. It was an invisible injury. He had just started playing for Yale as a freshman. He has one head injury. They didn't understand why he was not playing. So these individuals on his team told him to tough it out. They told him to "man-up" and they didn't want him around the locker room anymore.

Obviously this was very disheartening to Chris, and he tried talking to his coaches, who were very supportive of him, but they could not change the culture in that locker room from a few athletes who didn't understand why he couldn't play and didn't understand why he didn't "man-up." So after a while, he was medically disqualified. Those athletes eventually graduated and he

was definitely welcomed back to his team, to which he very much enjoyed being around. He wasn't able to participate in football anymore, as he was medically disqualified with six concussions. He is now graduating with his political science and economics degree, and he actually talks with the Sports Concussion Awareness and Prevention Program, which is based in Wisconsin, Connecticut.

But one of the things that we have found is changing in the culture is a very difficult thing to do. We have educated athletes and we have educated service members, and these individuals know the signs and symptoms of concussions, and the dangers, but we haven't found a way to change the culture. Athletes and service members will continue to play through pain, potentially knowing the affects and the dangers of their concussion.

Military recruits are immersed in military values and cultures, including devotion to duty, commitment, and service before self, and the idea that there is not a greater bond than the one they share with the people to their left and to their right, and this may make them reluctant to self-report their concussion. And due to this, we know that we need to find a way to change the culture within U.S. service members. We also need to find a way to change the culture for high school athletes, for college athletes, and professional athletes. And I think once we can find a way to change the culture we can make some very good decreases in the number of concussions and decreases in the number of long-term injuries that may occur.

So, finally, I have a polling question that I would like to ask you to conclude my presentation. Would you allow your son to play football, yes or no?

Well, I can tell you the answers are actually pretty equal. So, 48.4% said, yes, and 51.5% said, no, so fairly equal that individuals would not allow their son to play football. So that obviously, I think, has to do with some of this concern that we feel right now about concussions, and in particular sports that have a higher risk for a concussion.

I'd just like to thank everyone for listening to me, and I'd like to thank everyone for the opportunity to allow me to give this webinar on gender differences and sport-related concussions. And I'm now going to turn it over to Dr. Marion.

Alright. Thank you very much, Dr. Covassin. That was really interesting and very informative, so, much appreciated. I've got a little bit of product for you to sort of stop and need to go through, and then we'll get to the question-and-answer period. This month's highlighted product is the newly released, "A Parent's Guide to Returning Your Child to School After a Concussion." According to the Centers for Disease Control and Prevention, the rate of concussions in children has risen 60% during the past decade. Each year, more than 173,000 children and adolescents are treated in emergency rooms for concussions and other TBIs.

Children who have a concussion are expected to make a full recovery with the proper rest and treatment. The pace of recovery is unique for each child. Cognitive rest is important as physical rest. Advice varies widely, but in general, most medical professionals agree on this approach. Complete rest for the first 24 hours, gradually reintroduce activity, but stop any activity that causes symptoms to return.

Pushing a child to resume a full school workload too soon could set back his or her recovery. Most states have return-to-play laws to guide parents, teachers, and coaches. In fact, all states now do. But the area of return-to-learn varies from state to state. The 26-page "A Parent's Guide to Returning Your Child to School After a Concussion" offers practical advice to parents

on how to recognize the signs and symptoms of a concussion, information on treatment and recovery, and what a parent can do to support a child's recovery and successful return to school and related activities. Although written to help military families, this guide contains detailed practical advice for helping school-age children recover from concussions and is very useful for all families.

The Defense and Veterans Brain Injury Center developed the guide with a panel of experts from the Walter Reed National Military Medical Center; Children's National Health System Rocky Mountain Hospital for Children; Branches of Life in Chester, Virginia; and Woodlawn Elementary School in Alexandria, Virginia. For more information on TBI or to download "A Parent's Guide to Returning Your Child to School After a Concussion," please go to dvbic.dcoe.mil. You can also download this guide now from the files pod on the left-hand side of your screen.

All right, so it's now time to answer questions from the audience. If you've not already done so, you may submit your questions now via the question box located on the screen, and we'll respond to as many questions as time permits. And, Dr. Covassin, I hope we can get through, you know, five or ten of these, because they're really kind of interesting questions, and I'd like to start with a few. First of all, what data is there that menstrual cycle or birth control pills affect the concussion rate in women or girls?

So, we actually don't know the answer to the first question on whether or not the menstrual cycle affects them. We know that different phases of the menstrual cycle can affect their cognitive function, but in regards to actually looking at the menstrual cycle, there hasn't been any thing that has been conclusive. It has been studied a little bit in animal models, but at this point there hasn't been anything that suggests that when you are at a certain phase of your menstrual cycle that you shouldn’t be playing because you're at a higher risk for a concussion. I think also, when you think of the practicality of that, it's very difficult for, you know, the athlete and the coach, and even the parents, to consider during those couple of days that that individual cannot participate in sports because they may be at a greater risk for a concussion. So we get a lot of this in the ACL literature, where there are times where there are greater risk for ACL injuries, but we're still, from a clinical standpoint, not going to recommend them not playing. They're just going to have to be aware that they may be at a greater risk during that time.

At what point in the cycle would you guess that they might be more at risk given the increase and reduction in progesterone levels?

At this point, they don’t know. So, there have been -- they have been inconclusive results during different phases of it.

Okay. Next question I had was, you had a slide that suggested that ice hockey and women was -- that was associated with, I think, the most concussions per thousand exposures, what is the sport that causes the most concussions in women?

Ice hockey. So, actually, the sport that causes the most concussions in females, is that what you're saying?

Yeah.

Ice hockey.

Not soccer?

No, not soccer. However, to clarify this, the results that you saw are the results from the NCAA Injury Surveillance System, and there are very few NCAA teams that are sanctioned for women's ice hockey. A lot of women's ice hockey is considered club, and they do not keep any type of data on those individuals. So the data that's reported is based upon very few sports teams for women's ice hockey. And, yes, they do the athlete exposure with this, but when we consider women's soccer, almost every single NCAA school has women's soccer, whereas there's probably only -- and I am probably going to completely mess this up -- but maybe 30 women's ice hockey teams that are sanctioned by the NCAA, and very few of those teams actually participated in that data collection. So it's somewhat skewed, in that sense, but, you know, it is ice hockey. Even though they're not allowed to have body checking or collisions, there is still a lot of contact that occurs in ice hockey. So, they are definitely at a higher risk than soccer. But just from a general, you know, perspective, soccer is the most played sport in the world, that there's going to be more females playing soccer than girls playing ice hockey, unless you live in Canada.

Great. A third question is, all 50 states now have state laws regarding mandated removal from play if there's been suspected concussion in high school athletes, has this led to a reduction in the incidence of concussion, either in men or women in sports?

Unfortunately, at this point, we haven't been able to gather data to determine whether or not it has led in a decrease in the incidence of concussions. We do know that at this point we're very happy that all 50 states have passed the Youth Sports Concussion law. The problem with the Youth Sports Concussion laws is kind of twofold; one is, what exactly was in the law, and the second, is who is actually mandating the law or actually seeing if you are following the law. So, in the first one, there are some states that actually don’t even have the three basis things that should have gone into the law, which was if you suspect an individual has a concussion, they should be removed from play. That individual should not return to play until they are cleared by a health care provider, and that there should be some education for athletes and parents and coaches. Some laws don’t even state that. I know Arkansas laws say that they will actually just give money to do some research for a concussion, but they actually don’t have any specific requirements in their state law.

I know, personally, for Michigan, we actually exclude high school sports. So in our law it specifically will exclude all high school athletes from the law. So, because of that, it's very difficult to determine whether or not these laws have actually decreased the total number of concussions. But the other thing is that a lot of individuals still don’t even understand that the law was passed. So I can tell you in the State of Michigan that we ended up passing the law, and there were individuals who hadn't a clue that it was passed. And there are still individuals who don't know that it's passed because it wasn't marketed out there, so it wasn't very publically known that there was a law that was passed. And the other thing is, there's no money for anyone to actually look into these laws or do something about it for individuals that actually violate the laws. So, from a general, you know, all 50 states, at this point, because all of the laws are fairly new, there hasn’t been any research to determine whether or not it's actually been effective. One hopes that it is. So, one definitely is hoping that it is, but we're not particularly certain at this time.

Thank you very much. That was a very thorough response to a very complicated issue. I know a number of people talk about how you can pass laws and you can exchange information through knowledge transfer, but changing behavior is a totally different animal. And that certainly seems

to be the case here. The next question is from one of the people who called in. They asked, "In your recent soccer study, how did you define your exclusion criteria of chronic migraine?"

So, those individuals who were actually diagnosed with migraines and actually had migraines over the past six months. So, to be completely honest, we only had one individual who was excluded based upon chronic migraines, but they had to have had a migraine once in the last six months and diagnosed by some type of a physician who states that they have actually suffered from chronic migraines.

Alright. Next question: what equipment was used to determine scores for postural stability? And I assume the person is asking if you could describe just a little bit what the BESS is?

Yes. So, the BESS is Balance Error Scoring System, and that was actually developed by Dr. Kevin Guskiewicz out of UNC Chapel Hill. And the BESS is a postural stability test that involves six stances. Three of the stances are done on a firm surface, so just the regular gym, the floor, some type of firm surface, and then the same three stances are done on a foam surface, which is typically an Airex pad, so some type of six-inch -- kind of those squishy pads that you can use for rehab. And the stances that are included are feet together, hands on your hips, and that would be feet together on both the firm and the foam. You then will stand on your non-dominant leg, so a one-leg stance where you're standing on one foot on the non-dominant leg, hands on hips. And then you would stand in tandem, where the non-dominant leg is behind the dominant leg, and kind of your heels and your toes are touching, and your hands are on your hips.

Now, when you do the BESS, each of those stances are held for 20 seconds. And the individual has to close their eyes, so that is where it makes this balance very difficult. And then you, as an examiner -- so, first off, yes, it is subjective. You, as an examiner, are actually looking for the errors. So you are looking do they open their eyes? If they do, it's one point. Do they lift their hands off their hips? That's one point. Do they lift their rear foot or their forefoot up? That’s a point. Do they go into 30-degrees of adduction or forward flexion? That's also a point. Or do they completely get out of position? And over the 20 seconds you are going to add up all the errors that they make, with a maximum of ten. If they fall off the mat, you know, open their eyes, they get all those errors, it actually only counts as one error. So they wouldn't get five because they lifted their hands, opened their eyes, stepped off the mat; they would only get one error. And then you tell that individual to go back into position and you would continue to count the errors that they make over the 20 seconds.

A typical normal person for balance would have about 12 for all the errors in the six stances, so a combined total of 12; whereas, typically, a concussed kid is going to have way more than 12. They can get up to 18, to 20, to 22 errors because each of those stances can add up to ten. So, the maximum total errors could actually be 60. And it's typically standing on one leg or the tandem stance where they fall out of position a lot. A lot of times, you know, as soon as an athlete closes their eyes that's concussed, they actually start to sway or they actually get out of position. So, that is what we use. It is a subjective test. It was primarily developed for athletic trainers as a sideline assessment, but it is something that we can definitely do on the sideline in the first couple of days of a concussion to determine if they have any balance issues.

Alright. That's a great explanation. Thank you very much. I might add that Kevin has posted a YouTube video showing how to go through these tests, the BESS, on the Internet. So people can look that up. It's open access and a really nice resource.

One more question, Dr. Covassin, how are male versus female coaches reluctance to report or desire to win, and keeping players in the game assessed in your statistics? And the second part to this is how has your data been or is being distributed at the high school level, and are we permitted to share this information at local levels? So, two-part question, I guess.

I'll answer the first one, because I'm not really certain I understand the second one. So, I believe the first one was relating to male and female coaches and how they are in regards to athletes who have sport-related concussions. And that is an interesting question, because, to be completely honest, I haven't seen any data that has looked at the coaches and whether or not they're reluctant to actually tell somebody that their athlete has a concussion. So some of the research that I have seen has been fairly comparable.

Now, the question is, when you survey coaches and ask them, "Would you leave an athlete who has a concussion in the game," the question is are they lying and saying, no, when the reality is it might be a yes because they want them to continue to play. So, it's really hard, I feel, to get good data in regards to that. I haven't actually seen anything that has had differences between males and females. I know, again, from a clinical standpoint I can tell you that, you know, if you would have asked me this ten years ago I would have said, "Oh, the male coaches are the ones that are -- they're the ones that want to keep playing the athlete who has the concussion. They're the ones that are always saying don't tell the athletic trainer, don't tell your parents, don't tell your physician." But I think, ten years later, we're actually seeing some female coaches who are very competitive. We do know that females are faster, aggressive, and stronger, and very much more competitive, so some of these female coaches are tending to have those bad habits of potentially trying to hide the concussion. But in regards to actual research, I have not seen any research that has shown that there are differences between male and female coaches in the reporting of concussions.

Thank you, Tracey. I think we're going to have to stop at that point because of the time limitations. And I really appreciate this very thorough review of the male/female differences. And it appears that your message is that females -- women do appear to be somewhat more at risk in the same sports at comparisons, so great takeaway message.

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The next DCoE T2 webinar topic, "Integration of a Virtual Hope Box Mobile Application into Clinical Care," is scheduled for October, 16th, 2014, from 1:00 to 2:30 p.m. Eastern Daylight Time. The next DCoE psychological health webinar topic, "Mental Health and Women in the Military," is scheduled for October 23rd, 2014, from 1:00 to 2:30 p.m. Eastern Daylight Time. And the next DCoE TBI webinar topic, "Technology Interventions for TBI," is scheduled for November 13th, 2014, from 1:00 to 2:30 p.m. Eastern Standard Time.

So, finally, once again, Dr. Covassin, thank you so much. Truly a world expert, and a world expert quality presentation. Very much appreciated. And thank you all for attending this webinar. Have a great day.

And this does conclude today's conference. You may disconnect all lines at this time.