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AUTO+ MEDICAL

STAGES OF SAFETY

With rally stages spanning huge areas, how do organisers ensure the safety of spectators?

AUTO+MEDICAL

Contents

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Rallying is one of the most challenging forms of motor sport. And not just for the drivers.

Events draw huge crowds that line the stages for hundreds of kilometres waiting to get a fleeting glimpse of their heroes. Ensuring the safety of all who attend is a huge task that takes years of dedication and planning.

Thankfully, huge progress has been made since the dangerous days where spectators lined the sides of the road in precarious positions. In this issue, we focus on how to keep spectators safe and provide medical care in case an issue occurs.

In keeping with the rallying theme, we look inside the World Rally cars that bring safety and medical equipment to every stage of an event. Two-time World Rally Champion Marcus Gronholm details his recovery from injury after a major accident two years ago. And Pedro Esteban, Permanent Medical Delegate for the World Rallycross Championship, gives an overview of his work on the series.

There is also a preview of the 2014 Medicine in Motor Sport Summit, held in Doha, Qatar on 1-2 December. The biennial event forms part of the FIA General Assembly Week and will bring together a wealth of motor sport professionals to discuss the key medical issues that face our sport today.

I hope you enjoy the latest issue.

Professor Gérard Saillant
FIA Institute President

LETTERS

In this section, we print the best letters and emails received from readers around the world. We welcome comments on articles as well as suggestions for future content or insight into an area of motor sport medicine you feel would be relevant. If you wish to send in a letter or email, please direct it to: medical@fiainstitute.com

Dear Editor

One of the strongest messages that came out of the Serious Accident Study Group meeting in Singapore was an enthusiasm for setting up a means of facilitating communication between ASNs in the Asia-Pacific region, particularly for discussing the provision of medical and rescue services. As a result, work is now being done to set up an Asia-Pacific Motorsport Medicine and Rescue Network, using online resources. The aims of this network would be to:

- To provide a means of discussion between Asia-Pacific ASN medics to enable the evolution of the motorsport medical response in the Asia-Pacific region
- To facilitate the exchange of resources between Asia-Pacific ASN medics
- To create and facilitate a core group of Asia-Pacific motorsport medics who can provide education, training and aid decision making for motorsport medicine and rescue in the Asia-Pacific region

Perhaps, if this initiative proves productive, it might be expanded to other regions. There's only one way to find out.

Rgds,

MATT MACPARTLIN
DEPUTY CMO, RALLY AUSTRALIA

Editor: Read more about the Singapore event on p7

Dear Editor,

Once again, I have nothing but praise for the most recent issue of Auto+Medical. I had printed this issue to take with me while I waited for my car to be checked and prepped for a hillclimb. I was so surprised to see my name in print in the Letters to the Editor section!

The guys at the shop were impressed by the company I was keeping, at least in print!

Are there any long term plans for a peer reviewed journal? In the mean time, I would like to see the addition of some relevant peer reviewed articles reprinted from other journals. In lieu of that, might it be possible to add abstracts or at least a bibliography of recent publications?

Again, a useful and informative journal! Looking forward to the next issue!

Sincerely,

MARY ZEITNER, PA-C

Editor: We would welcome relevant peer-reviewed articles reprinted from other journals.

STAR LETTER

Dear Editor,

In Issue 2 of Auto-Medical Dr Steve Olvey provides an extremely informative and comprehensive review of Traumatic Brain Injury (TBI) in Motorsport.

TBI is the commonest cause of death in people under the age of 40 but as Dr Olvey describes in his article the mortality from this condition related to motor sport has decreased with time due to improvements in driver protection (helmets and head and neck support (HANS) device), car design (cockpit protection), track design (run-off etc.), medical response at the scene and in hospital. Overall improvements in mortality have been multifactorial and led by a number of specialists including car designers, engineers, pre-hospital medicine, emergency medicine, intensive care, neurosurgery and rehabilitation.

Dr Olvey correctly alludes to neurosurgeons becoming more surgically aggressive helping to improve mortality. However, we need to be cognizant of the range of outcome in survivors. While many make a good recovery, there is high incidence of varying degrees of disability (seen in both mild and severe head injury). The indications for surgery for mass lesions (particularly extradural haematomas and subdural haematomas) are well established but there are also surgical options for diffuse brain injury including drainage of cerebrospinal fluid by ventriculostomy and decompressive craniectomy (removing a large piece of skull to reduce intracranial pressure). This latter operation is controversial, the Australian-led DECRA study, showing no difference in mortality but a higher rate of unfavourable outcome in patients undergoing surgery compared to medical management. The European-led RESCUEicp study will report at the start of 2015. Until then, decompressive craniectomy should be judiciously applied.

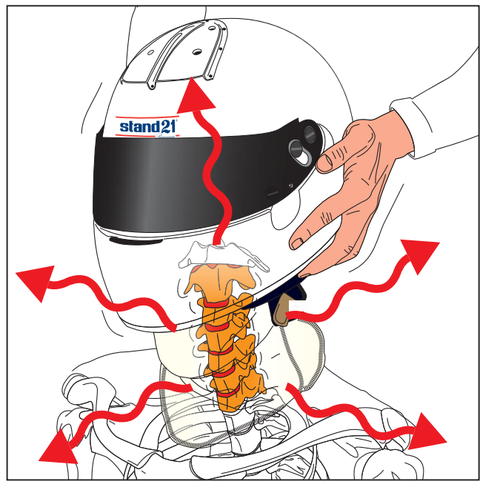
Medical treatments for raised intracranial pressure are also undergoing further investigation. Dr Olvey describes the role of hypothermia and this too has been subjected to a randomised trial by Eurotherm which has recently closed to recruitment.

Mild head injury, specifically concussion, is becoming an increasing concern in both motor and other sports. Dr Olvey eloquently describes the symptoms and signs of concussion and the various neuro-psychatric tests that can be applied. There is a need to provide improved guidance on the management of concussion in motor sport, both in terms of investigation, treatment and return to sport. More work is required in terms of the use of neuropsychiatric tests and imaging. While there are well established guidelines for the application of CT following TBI, the role of more advanced imaging including MRI shows great potential in the management of the condition and requires further investigation. For patients with on-going symptoms pituitary dysfunction should also be considered. In terms of return to motor sport following TBI, in addition to symptom resolution, consideration also needs to be given to the risk of post-traumatic seizure, potentially catastrophic if this were to occur while driving.

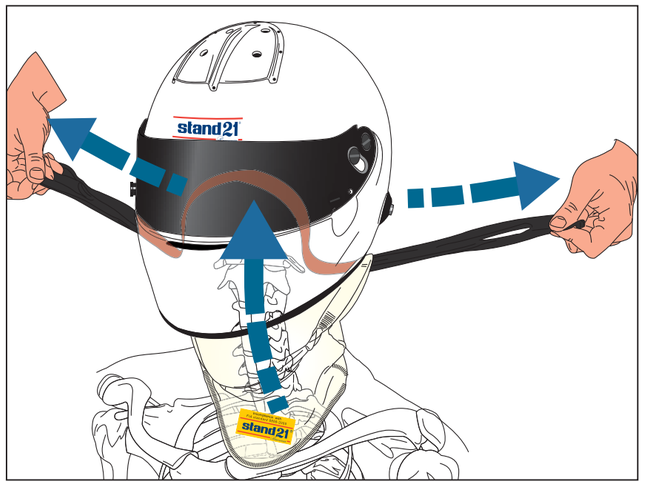
Overall there are several important research questions in terms of TBI in relation to motor sport. In the meantime patients should be managed on an individual basis, both in terms of acute management and return to sport, with sound clinical judgment supported by current guidelines.

PJ HUTCHINSON
PROFESSOR OF NEUROSURGERY, UNIVERSITY OF CAMBRIDGE, UK
CHIEF MEDICAL OFFICER BRITISH GRAND PRIX

GLOBAL NEWS



WITHOUT LID LIFTER HEAD SOCK



WITH LID LIFTER HEAD SOCK

NEW HELMET REMOVAL DEVICE

A helmet removal device called the Lid Lifter, which enables the delicate removal of the helmet from a driver's head following an accident, has been produced by motor sport safety manufacturer Stand 21.

The Lid Lifter head sock has been developed by a number of expert medical motor sport professionals, including World Rally Championship Medical Delegate Dr Jean Duby.

To minimise the risk of irreversible damage to a driver's cervical vertebrae post-accident, medical staff usually try not to remove the helmet on site. However, in some cases removal of the helmet is ultimately necessary to provide life-saving medical care.

Made from an exclusive airy fabric offering both comfort and protection, the Lid Lifter fits easily over a driver's balaclava and features straps to uniformly lift the helmet from the head.

The Lid Lifter is certified to the FIA standard and has been used in a number of training exercises, including an extrication seminar at the Le Mans Circuit in France. It comes in two sizes and is a natural white colour with black handles.

FIRST FIREPROOF BRA DEVELOPED

Motor sport safety manufacturer Stand 21 has developed a fire-retardant bra specifically for female racers.

Working alongside IndyCar medical and safety experts Dr Terry Trammell and Jenny Stewart, Stand 21 created a prototype bra that was then tested for several months in both the IndyCar series and drag racing in the United States. Melanie Troxel and Alexis DeJoria, both drag racing drivers, gave positive feedback and felt extremely comfortable wearing the Stand 21 fireproof bra.

The idea for the project started when Dr Trammell approached Stand 21 founder Yves Morizot after he noted that traditional bras could be dangerous in the event of an accident. Fire was of particular concern to Trammell and he wanted to look for a solution.

Following a meeting with Michele Mouton, President of the FIA Women & Motorsport Commission, it was agreed that the issue should be tackled and a fireproof bra was developed for female racers for the first time.

The bra contains no metal or plastic underwire, which eliminates the risk of burns to the skin. It is made from an Aramid fabric and comes in a number of sizes. The product has been granted SFI 3.3 certification, which ensures it will perform to high safety standards in the event of an accident.

SINGAPORE HOSTS FIRST TRAINING EVENT

The Serious Accident Study Group (SASG) held its first regional training event on 4-5 October in Singapore.

The two-day event, hosted by the Singapore Motor Sports Association (SMSA), covered numerous topics including extrication, stabilization and evacuation of seriously injured casualties. A variety of expert speakers selected by the FIA Institute, including members of the Singapore Grand Prix medical and race organization teams, were on hand to deliver lectures.

Workshop sessions were held that enabled participants to gain practical experience in extrication with both open and closed cockpit cars. The sessions drew from the knowledge of many of the attendees and found that many medical teams across the Asia-Pacific region face similar challenges in this area.

Other topics covered included event planning, where in-depth seminars gave advice on establishing disaster plans and effective working protocols during a race, and first-on-scene response.

Dr Kelvin Chew, Chief Medical Officer for the Singapore Grand Prix, said: "The sessions highlighted the need for more regional events and for better communication between ASNs to aid education, research and development. We were proud to host this inaugural regional meeting and have the FIA Institute to thank for their on-going efforts in promoting motor sport safety."

Leslie Chang, President of the SMSA, added: "The meeting provided a valuable opportunity for the participants to work closely with international experts from the motor sport medical field. Most importantly, it has successfully created a platform for representatives from regional ASNs to interact freely and implement initiatives."

Following the successful completion of this first event, it is hoped that more regionalised training events can be held across the world to enable a wider cross-sharing of medical knowledge and information in motor sport.

The SASG was established by FIA President Jean Todt to collate data from accidents where life had been, or potentially was, threatened. The study group then evaluate the data and make recommendations to improve safety whilst working with global medical experts from other sports.

PROF SID WATKINS HONOURED

UK neuroscience hospital The Walton Centre has named a new facility in honour of former FIA Institute President Professor Sid Watkins.

The three-storey building, which opens in Liverpool in January 2015, will house a rehabilitation unit, pain management programme and medical training facilities, as well as Mersey Care's brain injuries unit.

The naming has been welcomed by three-time Formula One world champion Sir Jackie Stewart OBE, who said: "He was one of the greatest men of medicine that I have ever encountered. His dedication to constantly finding new ways of doing things, to give people another chance to enjoy life, was a huge asset to both the world of medicine and to those who were fortunate enough to have his help and talent to provide life."

Prof Watkins' wife Susan added: "My husband would have been proud to know that his name has been attached to this rehabilitation facility, both its calibre and scope reflect his own attitudes to patient care, and his concern for the on-going needs of those who suffer from neurological diseases and injuries requiring long-term treatment. In this way it is a reflection of his life's work and, in a sense, brings him home to his roots in Liverpool."

Watkins was made head of the on-track medical team in Formula One in 1978 and helped to revolutionise medical care and safety in the sport. In 2004 he became FIA Institute President, where he enabled the continued advancements of safety and care in this area. He retired in 2011 and passed away the following year, at the age of 84.

PAN-AMERICAN CONGRESS HELD IN MEXICO

The Organizacion Mexicana del Deporte Automovilistico Internacional (OMDAI), Mexico's National Sporting Authority, hosted the inaugural FIA Pan-American Medical Congress in Acapulco on 12-14 November. Over 120 doctors from 15 nations across the region attended, with more than 20 national and international speakers delivering lectures at the event.

The three-day event looked at safety and trauma interventions in motor sport. It is the first FIA medical event to bring together knowledge and expertise from across North, Central and South America.

The congress focused on training both experienced and rookie motor sport doctors and medical staff. A variety of presentations, workshops and discussions took place looking at a number of topics including practical extrication, major trauma and car and road safety. Electric and hybrid vehicle safety was also discussed as a key emerging issue in motor sport.

The FIA Institute supported the Congress and led a dedicated session on medical and safety issues at rally events. Chief Medical Officers Dr Jean Duby, Dr Manuel Alberro and Dr Michael Scholz presented and led a discussion on the topic.

Jose Abed, President of OMDAI, said: "It was an honour to welcome such an important group of doctors. I hope participants will take back home a great experience from this congress and that we will see them soon, being part of the action, in motor sport events."

The congress concluded with the promise to create a medical degree specializing in motor sport in the near future, with the collaboration of the Universidad Nacional Autonoma de Mexico.

It is hoped that following the successful completion of this first congress, the event can become an annual, cross-continental platform for medical professionals working in motor sport to share information and increase the dissemination of knowledge in this area.

EARNHARDT JR RAISES CONCUSSION AWARENESS

NASCAR Sprint Cup driver Dale Earnhardt Jr has joined up with The Sports Medicine Concussion Program at the University of Pittsburgh Medical Centre (UPMC) to raise awareness on concussion treatments.

UPMC has recently unveiled a website – ReThinkConcussions.com – to outline the different treatments that are available for concussion. Earnhardt features on the website, detailing his own story on concussion and the problems that were caused by not seeking immediate treatment.

In the video, Earnhardt explains that his problems first began in August 2012 following a testing crash at Kansas. He continued to drive for several weeks before a second accident at Talladega caused another concussion.

"As soon as I got out of the car, I was like 'Something is wrong with my head again,'" says Earnhardt. "I was really moody, very angry, I couldn't go anywhere where people were. I was very scared."

The 40-year old was forced to sit out the next two races and sought treatment at the UPMC. His situation also led NASCAR to begin baseline concussion tests for all drivers for the 2014 season and beyond.

Dr Micky Collins, the Clinical and Executive Director of the Concussion Program at UPMC, said: "An important reality is this: concussion is treatable if managed properly. People should think of concussions as a treatable injury in the right hands, not some untreatable condition that causes you to retreat to a dark room."

GERMANY BECOMES TRAINING PROVIDER

The Deutscher Motor Sport Bund (DMSB), Germany's National Sporting Authority (ASN), has become an FIA Institute-approved Medical Regional Training Provider (RTP).

The ASN recently reached the top level of accreditation, Achievement of Excellence, in the Institute's Medical Programme. Following a thorough evaluation of medical practices and educational skills, the ASN was then awarded RTP status. They will now offer events to help train other medical officials and ASNs in their region.

The Medical Accreditation Programme enables ASNs to achieve the highest standards for medical training and practice. They can be accredited at three levels: Commitment to Excellence, Progress to Excellence and Achievement of Excellence. Those that reach the highest standard can then apply to become an RTP for medical training.

At the FIA Sport Conference in Munich in June, the DMSB exhibited its medical expertise with a full-scale disaster response demonstration. Having set up an indoor scenario involving an explosion in a garage at a circuit and multiple casualties, the medical team from the DMSB showed how to deal with such a situation in the correct manner.

AUTO+MEDICAL FEATURES

FEATURES

STAGES OF SAFETY

Every year, the FIA World Rally Championship welcomes hundreds of thousands of spectators to its events across the world. But with rally stages spanning huge areas, how do organisers ensure the safety and welfare of spectators?

Spectators watch the action from designated areas at the 2014 Wales Rally GB

In rain or shine, snow or sun, World Rally Championship (WRC) fans attend rally events in their thousands. They are some of the most enthusiastic and passionate motor sport spectators in the world.

For event organisers this is both a blessing and a curse. It is great to have support for your event but it is also a logistical nightmare to keep those supporters in the right areas at the right times to guarantee their safety. So how do they achieve this?

It all starts with a safety plan. The FIA requires each rally organiser to produce a thorough and detailed safety plan covering a number of areas before it can go ahead with an event. The plan outlines spectator areas, medical provisions and other safety details that enable the rally to run smoothly.

FIA Rally Safety Delegate Jacek Bartos is the man who oversees this process. “Each rally organiser has to produce a standard safety plan that meets the rally safety guidelines,” he explains. “It is difficult to compare different rallies, such as Monte-Carlo to Mexico, but every organiser should ensure its plan looks as similar to others as is possible.”

Each organising body is responsible for the level of safety on their own event. The role of the Safety Delegate is to control and oversee that everything is in place and runs according to plan. Bartos says: “I work during each WRC event to ensure spectator safety as well as official and marshal safety. I check during the rally to make sure that the safety plan is being implemented correctly.”

For a WRC rally stage to start or continue, he has to be convinced that all safety measures are in place. For the safety plan to be successful, marshals are vital.

Bartos, who has been in charge of crew and marshal safety in the WRC since 1993, says: “The role of the marshals is very important. Many of the organisers have sections where they can put in very experienced people and they know exactly what to do. They know how to organise and how to get spectators along the pathways in a controlled manner.”

“WE HAVE 1,700 MARSHALS ON THE EVENT COVERING 4,800 LOCATIONS.”

He believes that the standard of marshalling has improved dramatically since he first took up his current role. “Some events have had problems with the standard of marshalling but I can say that at the very least, very experienced safety marshals cover 75 per cent of all events.”

To aid the standard of marshalling across different events, Bartos has helped to develop tools to improve marshal training. “Personally, I have prepared training videos and materials for marshals, which have proved useful. We use them at safety seminars and show them to marshals working not only on WRC events but regional and national championships too.”

He is clearly passionate about his role and is involved in aiding the FIA in improving spectator safety at all rally events, not just those on the WRC calendar. Bartos explains: “We are pushing to get the rally safety guidelines for WRC events to become mandatory at national and regional events. That will definitely help to improve safety at that level.”

Event Focus

Bartos’ experience is a valuable help to organisers of each individual WRC event in maintaining and improving spectator safety. That is certainly the opinion of Charley Webber and Sue Sanders, who are in charge of safety at the popular Rally GB, where thousands of spectators cram into Welsh forests each November.

“We are constantly learning and constantly trying to make it safer for everyone,” says Sue Sanders, who has been involved in motor sport for over 35 years. Her task as Event Safety Co-Ordinator encompasses a wide range of elements: spectator and sporting safety, medical, the training element for marshals and their recruitment.

She is supported by Charley Webber who, as Chief Safety Officer of the event, has an equally challenging role. “Under my control are the rescue, medical intervention and recovery vehicles. I mobilise them in the event of an accident and advise the Clerk of the Course as to what to do on the scene of an accident.”

Planning and drafting of the necessary safety plan required by the FIA is a long and arduous process. It goes through a number of drafts before the actual event begins and enables everyone involved to make suggestions, particularly in the area of spectator safety. And there are a lot of people involved.

“We have 1,700 marshals on the event covering 4,800 locations. We have 21 doctors and 7 paramedics along with these,” says Sanders. “When discussing spectator safety, it is up to the stage commanders to interpret what we put forward and to have the confidence to challenge us if they think something could be better. It is very much a two-way process.”

Having key people throughout the stages who are both experienced and trustworthy

MSA's Sue Sanders and FIA's Jacek Bartos go through the safety plan for the event

is absolutely vital to maintaining spectator safety. Marshal training is therefore given a major focus before each year's event. "It is a big part of it. We have to train the stage commanders so they know how to set the stages up. For regular marshals, the Motor Sports Association (MSA) delivers training every year from January to March. The event runs briefings from August onwards for marshals, specifically looking at how an international event works including extra challenges, such as the number of spectators and other things."

To ensure spectators are not stood in dangerous areas, Sanders and her team mark the stages out with specific plans for each spectator area. "It shows where they can and can't stand. Anything that is not classified as a spectator area may have marshals posted there but we don't expect enough people in these areas that it will be an issue."

This leads to large groups of spectators congregating in the special spectator areas and marshals need to be vigilant to keep control. "The marshal's role in spectator areas is to ensure that spectators stay behind the rope or tape and don't escape those areas. They do that through training, they wear tabards and each area has one official that is in charge of a specific sector. They have radio contact with the stage commander so they can get assistance if needed."

Another level of security is provided in these areas where large numbers of fans are expected. Sanders continues: "In certain circumstances, we will also have qualified stewards to help marshals with large crowds. When the rally cars come through, their primary objective is to support the marshals and ensure everyone stands in a safe area."

Sanders believes that the standard of marshalling has greatly improved and thus the risk to spectator safety has lessened. Technical advances have enabled this. "It is now 20 years since we first introduced the radio system and that has helped. Before this, we used to let people roam anywhere in the forest and didn't have spectator areas."

However, having these dedicated zones for the fans has added an additional layer of complication. "Even though we had a lot of people to manage, because they weren't collected in one area, they were slightly easier to manage. Now that we are putting them into specified locations it is slightly more difficult to manage. It is definitely safer though."

Even so, there is always the chance that spectators can be injured during a rally, no matter how many safety precautions are put in place. If the worst-case scenario should occur, a number of provisions are in place to aid any casualties.

Charley Webber, Chief Safety Officer, explains: "We actually have two separate medical facilities, one for competitors and one for spectators. We have a first-aid station, manned usually by St John Ambulance, at each spectator area. We have ambulances specifically for spectators as well and they can transport them out of the stage to the relevant treatment centre."

If it is a particularly serious injury, all medical provisions can, and will, be mobilised. "We can send our own competitor-based medical facilities to help them. We have done that in the past and we will do it again."

Perhaps the most impressive thing about spectator safety on WRC events is that the majority of the people involved are volunteers. "All the people in the vehicles, medical or rescue, are volunteers," says Sanders. "The paramedics and doctors all work for a very small fee but they support the event because they love it."


Chief Safety Officer Charley Webber checks on the marshal posts for each stage

They have to love it, as it is no easy task either to be involved as a marshal, paramedic or doctor on a rally event. "They work really long hours," says Webber. "On the first day of the event they will be up at 3:30am to travel to their particular stages. I doubt they will be back at their accommodation before 7pm in the evening. They all do it for the love of the sport."

Most spectators will head out on to the stages to see their heroes drive at breathtaking speed through the tightest of turns, with little regard for the effort that has gone in to keeping them safe. With the supreme logistical planning, ably supported by an army of dedicated volunteers, they are able to do this at every WRC event and return home safely with memories that will last a lifetime.

CHIEF MEDICAL OFFICER PROFILE:

DR PEDRO ESTEBAN

Permanent Medical Delegate, FIA World Rallycross Championship
Deputy Medical Delegate, FIA World Rally Championship
Deputy Chief Medical Officer, Circuit de Barcelona-Catalunya

Having started his motor sport medical career at his local circuit, Dr Pedro Esteban is now travelling the globe as Permanent Medical Delegate for the new FIA World Rallycross Championship and Deputy CMO for the FIA World Rally Championship.

As a long time motor sport fan, Dr Pedro Esteban had no hesitation when he was asked to cover for a colleague during race day at his local circuit ten years ago. His passion soon turned into a serious pursuit taking him across the world as a medical delegate and Chief Medical Officer (CMO).

In this interview, he explains how he deals with the commitments of his various roles and why he is determined to continue improving medical care in motor sport.

AUTO+ Medical: How did you first get involved with motor sport?

Pedro Esteban: It was in 2004 during my Orthopaedic training in Barcelona and the person in charge of the hospital was going to Circuit de Barcelona-Catalunya. He asked if I was available to replace a trauma surgeon for a race day so that is how I got involved with it. I was already a big fan of Formula One and rallying.

A+M: What were your first experiences of working at a circuit?

PE: I was located in the extrication team as the doctor. The cars were lovely and I remember perfectly that the sound and the smell were amazing. It is difficult to explain to other people but I really felt the atmosphere. I was there more like a fan than a doctor!

A+M: What is it like to be a doctor in the medical centre following an accident?

PE: I have worked in a number of different positions but mainly in the medical centre. We are able to follow on TV the action on track. We usually have seen the accident and how the extrication team is working so we have the information and have time to plan how to receive the casualty.

I sometimes work in the medical car though and you are the first responder. You have to be clear in your mind to provide the ABC of care to help the injured party. We feel the pressure when working to help someone because of the TV audience and the press.

A+M: You are now the Permanent Medical Delegate of the World Rallycross Championship. How did that role come about?

PE: I spoke with Jean Duby (FIA Medical Delegate for the World Rally Championship) and he told me a new championship was coming and they wanted me to take this position. I was really surprised but really happy and I have to give thanks to the FIA Medical Commission for choosing me.

A+M: What does your role involve?

PE: I receive from the Chief Medical Officers (CMOs) of each event the medical questionnaire. I have to check and verify if it fits with the safety

AUTO+MEDICAL FEATURES

Round 8 of the 2014 FIA World Rallycross Championship in Loheac, France

criteria. When I arrive at the event on Friday I have to check all the hospitals that we may use, including intensive care and surgery theatres. We also do an extrication exercise with the local doctors to practice removing the drivers safely. During Saturday and Sunday I am in race control to help coordinate the response to any incidents on the track.

“WE HAD TO TREAT ABOUT 90 PEOPLE IN AN HOUR.”

A+M: There have been a number of incidents in World Rallycross this year, have these been difficult to deal with?

PE: Not really. We had a major concern at the beginning with a few incidents involving fire - 13 cars so far have caught fire. When I go to the track now I explain to all local doctors this problem. We have had one major accident with a rib fracture but so far it has been really safe. I am crossing my fingers that this continues.

A+M: Are you enjoying World Rallycross?

PE: Absolutely. I didn’t know what I was going to see so it is a good surprise. The public being able to see the whole track from a single position is great and an interesting formula. Seeing six cars race every three or four minutes is really fantastic.

A+M: You also have a role with the World Rally Championship, what is that role?

PE: I replace Jean Duby as the Medical Delegate when he is unable to attend. I don’t go to every round, only when he is unavailable. This year I have been to Poland, Portugal and will go to Wales too.

For the WRC, what we do is check the medical position in each place. That means we have to check each stage an hour before the rally cars take to it. It is exciting but quite stressful.

Once we finish the inspection we go to rally headquarters with the local Chief Medical Officer.

AUTO+MEDICAL FEATURES

A major concern this season is the number of cars that have caught fire

A+M: How much more difficult is it in dealing with an accident on a rally?

PE: Rallying is difficult to deal with. The idea of the regulations is to have a medical point every ten minutes, below 15 kilometres. If there is an accident you have to deploy one of the medical cars and sometimes one of the extrication cars. They have to get there less than ten minutes after the accident. Jean Duby has put a great effort in to train crews to perform first aid on another injured driver because the first responder will usually be the competitor directly behind. Maybe two or three competitors will get there before any medical help can get there. I am at race control and we have digital maps that show yellow in a section if there is an incident with a car and red if something is really wrong and they need medical assistance.

A+M: Has there been a moment in your motor sport career that has been particularly challenging?

PE: It was four or five years ago when there was a fire in the Williams garage after the Spanish Grand Prix. There were just three doctors as we walked through the paddock and suddenly saw a column of smoke. People were running away but fortunately there were no serious injuries. We had to treat about 90 people in an hour. Seven of these were sent to the hospital and it was really a challenging moment.

A+M: How have you combined your work in motor sport with your day job at the hospital?

PE: It used to be really difficult. I am working in Andorra at present and I work there Monday, Tuesday and Wednesday. It is fantastic to be able to combine all the motor sport events with my day job. It would be difficult to have to ask to change my schedule to accommodate all these motor sport events.

A+M: Does that leave much time for yourself and your family?

PE: This is a key point. I am married and have two daughters but they are very understanding. It is difficult when I have no weekends free but with FaceTime and Skype it is a little bit easier.

A+M: What are your plans for the future?

PE: I am really confident that I will be involved in the World Rallycross Championship. When I speak with other people they are all very upbeat about the future for it and we have organisers from China and other countries who are interested in organising an event. The plan is to be involved with this as long as possible. As Permanent Medical Delegate we also go to the FIA Medical Commission and this is a great place to learn. We get to talk about how we think we can improve medical care and my main target is to be involved with them as well.

AUTO+MEDICAL FEATURES

DOHA DEBATES

Extrication, electric vehicle safety and concussion are just some of the many issues to be discussed at the 2014 Medicine in Motor Sport Summit. The two-day event will see professionals working in motor sport from around the world gather to discuss a range of medical and safety topics, helping to raise standards worldwide.

Aspetar Hospital, the first specialised Orthopaedic and Sports Medicine Hospital in the Gulf.

Doha, the ever-expanding capital city of Qatar, will play host to one of the largest and most important medical conferences in motor sport. The 2014 Medicine in Motor Sport Summit, jointly organised by the FIA and the FIA Institute, will see senior figures in motor sport medical care deliver a series of seminars, lectures and workshops over two days on 1-2 December. Forming part of the FIA General Assembly Week, the biennial event will enable a wealth of delegates from a variety of backgrounds to gather, discuss and learn more about key subjects relating to motor sport medicine.

One of the key themes of this year's event will be electric and hybrid safety. There has been an ever-increasing push in recent years to develop this technology, with Formula One, the World Endurance Championship and the newly launched Formula E series, all contributing to a new era in motor sport. Medical care and safety provisions need to be adapted and developed for these vehicles and this will be discussed in length at the summit in Qatar.

Following opening welcomes from FIA President Jean Todt and FIA Institute President Gérard Saillant, a round table discussion will take place on electric and hybrid safety, chaired by Formula E Medical Delegate, Dr Phil Rayner.

Other round table discussions will be held on the morning of the first day, with rally safety and concussion scheduled to be discussed. These are two critical areas of study in motor sport medical care currently and the sessions will be led by a number of industry experts including Jean Duby, FIA Medical Delegate for the World Rally Championship and Pedro Esteban, Permanent Medical Delegate for the World Rallycross Championship.

Following the conclusion of these sessions, the Chief Medical Officers (CMOs) Seminar will begin the afternoon schedule. The biennial event will see CMOs from Formula One, the World Rally Championship and Formula E, discuss and debate their experiences and make recommendations on how to improve medical care across the sport. The second part of the seminar will take place the next day, with CMOs from the World Endurance, Touring Car and Rallycross Championships, sharing their knowledge.

Innovative papers will be presented by numerous medical professionals on day one, with an intriguing array of topics to be discussed. Subjects include reforming extrication teams to de-clutter the post-accident scene, stress-level monitoring and an in-depth look at the medical management

Previous Summits have been held in Istanbul, Valencia and Bahrain

of competitors following a four-year study held at the Silverstone Circuit in Great Britain.

A presentation of the FIA Accident Database will also be given and Dr Michael Scholz, Chief Medical Officer of the German Grand Prix along with Dr Ian Roberts, Formula One Medical Rescue Coordinator, will provide insight into two exciting projects. To help create one uniform standard and approach across global motor sport, an FIA-approved basic medical course will be developed and a new edition of the Institute's Medicine in Motor Sport book will be released in 2015.

Dr Scholz and Dr Roberts will outline how these projects, in conjunction with the programmes already run by the FIA Institute, can help to reach a higher standard in medical service across the world.

The FIA Medical Commission will also meet at the end of the first day, to discuss any medical matters raised by its members.

Day two of the summit will feature a more hands-on experience as attendees spend the day at the world-renowned Aspetar Hospital, the first specialised Orthopaedic and Sports Medicine Hospital in the Gulf. These state-of-the-art facilities will host a range of workshops, practical exercises and interactive discussions under the guidance of leading sports medicine practitioners.

Dr Hakim Chalabi (Aspetar's Assistant General Director for International Medical Affairs and Programmes and Centres of Excellence - Executive Director for National Sports Medicine Programme) will give a keynote speech on what motor sport medicine and sport medicine can learn from each other. Workshop sessions will then begin with closed car extrication, burns and hazards, resuscitation and concussion all covered.

The FIA Institute has supported similar workshops over the past year. Along with the Serious Accident Study Group running its first regional training event recently, great efforts are being made to train as many medical personnel as possible in the correct procedures to implement following an accident. The workshops at the summit will enable a large number of attendees to gain vital practical experience whilst being overseen and guided by motor sport medical care experts.

After the successful conclusion of all workshops, closing remarks will be made by Gérard Saillant to end the 2014 Medicine in Motor Sport Summit.

Speaking ahead of the event, Jean Todt said: "It is a vital forum for the discussion and debate of a variety of safety and medical topics by motor sport professionals. The summit is a key tool in improving motor sport safety and medical care, which is an ever-continuing mission."

Gérard Saillant added: "It will be an action-filled and informative schedule that will stimulate debate and discussion around key focus areas. The FIA Institute is once again pleased to jointly host such an important event that enables motor sport medical professionals to come together and discuss important matters in motor sport medical care."

This will be the fifth iteration of the biennial event, with previous summits being held in Istanbul, Valencia, Bahrain and the Paul Ricard circuit in France. Since its inception, the event has established itself as a key feature on the motor sport calendar. It now takes a multi-disciplinary approach with attendance from over 150 delegates from a variety of backgrounds, including physicians, engineers, researchers and technicians, who are encouraged to interact with each other and exchange ideas.

An extrication demonstration at the 2012 Summit in Istanbul.
Above: Previous Summits have been held in Valencia and Bahrain

INSIDE THE WRC MEDICAL AND SAFETY CARS

Rally GB Chief Safety Officer Charley Webber talks through the various pieces of equipment inside the medical and safety cars at every World Rally event.

Rescue Ambulance

The rescue ambulance contains all the vital equipment that is necessary in a serious rescue scenario.

1 HYDRAULIC PUMP
"The hydraulic pump is petrol powered and provides the drive to the tools. It is vital in providing the power we need to operate all the other tools in the vehicle."

2 CONNECTING HOSES
"The orange and green connecting hoses enable us to feed the power to whichever piece of equipment we require."

3 HYDRAULIC RAM
"A long, cylindrical tool, the hydraulic ram can be used for either pulling or pushing bent bits of metal. This is particularly useful if a part of the car, for example the roof, has been crushed on top of the driver. The pressure of the hydraulic system pushes out the hydraulic ram and can exert a great force on the metal. As it has a double acting circuit, it can pressure in both directions, so you can attach a chain to use it for pulling metal too."

4 SPREADING TOOL
"As with all the other hydraulically powered equipment, the spreading tool is operated using a twisting control level. We use the spreading tool if a door is jammed as it is extremely useful in opening up gaps. At its fullest extent, the tool can open up to 18 inches."

5 CUTTING TOOL
"The dedicated cutting tool is used to remove any part of the car that is interfering with the extrication process, be it the roof, the side of the car or the roll cage tubing or pillars. It is capable of producing a force over 100 tonnes so is extremely effective."

6 FIRE EXTINGUISHERS
"The vehicle contains two separate types of fire extinguisher. We have a dry powder and a water-based foam extinguisher, which are used in tandem. The powder extinguisher can knock down a fire before the foam is used to cool the area down to stop it reigniting. We use the foam extinguisher on fuel spillages as it can prevent leaking fuel from igniting."

Medical Intervention Vehicle

A Medical Intervention Vehicle is stationed at various, uniform distances throughout a rally stage and, if required by the stage commander, will drive to the scene of an accident to provide medical assistance to any injured party.

1 KENDRICK EXTRICATION DEVICE
"The Kendrick Extrication Device or KED is a semi-rigid brace that secures the head, neck and torso in an anatomically neutral state. It is vital in reducing the possibility of additional injuries when extricating a patient from a stricken vehicle."

2 LIGHT DISINCARCERATION EQUIPMENT
"Used in situations where a driver or co-driver may be trapped but does not warrant using heavier equipment as seen in the rescue ambulance. The Light Disincarceration Equipment contains a reciprocating saw that achieves a cutting action through a pull and push motion among other smaller items."

3 TOOLKIT
"With rally accident scenes and situations varying quite drastically, a multi-purpose toolkit is useful. It contains a number of general tools, sockets, spanners, hammers, panel cutters and ratchet straps."

4 TRAUMA BAG
"For use in serious accident, the trauma bag is used to treat severely-injured casualties. It covers a number of situations from a burns victim through to a non-breathing patient. It contains Burnshield dressings, trauma dressings including haemostatic dressings, two mini tracheostomy kits, spare intravenous fluids and a number of splints."

5 IMMEDIATE RESPONSE BAG
"Often used in conjunction with the trauma bag, the immediate response bag contains a number of useful items that can help an injured patient immediately. Oxygen is available, a stethoscope and dressings for minor injuries, through to airways, a suction box, collars and intravenous cannulation."

6 RESUSCITATION DRUGS BOX
"One of the worst-case scenarios we can face is finding a casualty with no pulse. In that case we would begin the resuscitation process and there are a number of drugs we use in this procedure, which are contained in this box."

7 MONITORING AED
"An Automated External Defibrillator (AED) can help revive a patient who is without a pulse. A monitoring AED provides additional information on its graphical interface, which can help improve first-on-scene care and improve the likelihood of survival."

8 FIRE EXTINGUISHERS
"As with the rescue ambulance, the medical intervention vehicle contains two types of fire extinguisher: dry power and water-based foam. These can be used together to fight any petrol-based fire."

9 FIRST AID KIT
"For minor injuries, we carry a first aid kit that contains plasters, tape, sterile dressings and other assorted bits."

10 ENVIRONMENTAL OIL SPILL KIT
"In large accidents, cars can lose oil and this can prove an environmental hazard. We carry an environmental oil spill kit that contains sorbents to absorb oil and reject water. They are tested to the very highest standards and can deal with any spill that may occur."

AUTO+MEDICAL FEATURES

THE ROAD BACK:

MARCUS GRONHOLM

Two-time World Rally Champion Marcus Gronholm has experienced a number of accidents in a career spanning over 20 years. But it was whilst competing in the Global Rallycross Championship during the 2012 season that he suffered one of his worst injuries.

Gronholm was knocked unconscious when his Ford Focus struck an exposed concrete light pole base on a practice run at the X Games event in Los Angeles. The accident would leave him in hospital with serious injuries and a new perspective on his career. The Finn details to AUTO+ Medical his recovery and the impact the accident has had on him and his family.

AUTO+ Medical: What do you remember about the crash?
Marcus Gronholm: I don't remember anything about the crash, as I was knocked unconscious. I still can't remember how it happened and I still don't know why it happened.
A+M: What was the extent of your injuries?
MG: I was unconscious when I was admitted to the hospital. I had some bleeding on the brain but they managed to stop that. It could have been really bad but luckily it stopped and they made sure there was no pressure on my brain. I was in hospital for a number of days and they did a lot of scans to make sure that everything was going ok. It was a scary time.
A+M: What were your first thoughts when you were informed of what had happened?
MG: It was the first time in my life when I had had no idea why I had crashed. Normally I know during an accident that I have made a mistake and am going to crash and I remember that. But this time it had just happened. I might have tried to cut the corner but I don't know why I hit the concrete pole. I have watched the video and I still can't come up with a reason why it happened.

A+M: How was the medical care you received both from the X Games team and the hospital staff?
MG: The X Games medical care wasn't so professional. The doctors in the hospital though were very good and we got all the help we wanted. I had nothing to complain about and everything they said was confirmed when it was checked.
A+M: How did the treatment you received compare to that drivers receive in FIA organised events?
MG: I think it was more hassle with the track. There was so much going on and they had to change the track for practice. The track we were using was going to be changed from practice to the race also. It is not so easy to make a track in the city of Los Angeles that is both good and safe. I definitely think there could have been better safety precautions as there are on FIA organised events.
A+M: How did you feel as you began the rehabilitation process?
MG: It was nice to get out of the hospital. I wanted to stay there until everything was fine

AUTO+MEDICAL FEATURES

Gronholm competing in the Global Rallycross Championship at the X Games event in Los Angeles before his accident

and I stayed a few more days with my wife in the United States as I wasn't sure if I could fly. The doctors said it was fine but we took some extra days just to relax. When we did fly home though everything was fine so I was happy and lucky.

A+M: At what point was it clear that you would recover sufficiently to be able to drive again?

MG: I wanted a time where I wasn't doing any sports. I decided during that period that I wasn't going to race and that came from some family pressure as well. They didn't want to have to come and pick me up from the hospital anymore. It was quite easy to come to terms with that surprisingly. From time to time I do miss it but I am completely fine from the crash and can drive just as well as normal.

A+M: When you got back in the cockpit, what were your thoughts and emotions?

MG: I didn't feel scared because I didn't remember anything from the crash. It felt like I hadn't been out of the car at all. It felt exactly the same as before. I believe I could compete at the same level as I could before but maybe I am getting older so I can't anymore. I was lucky though and I am happy that I don't need to compete, that feeling has gone.

A+M: Has the crash changed your views on medical care in motor sport in any way?

MG: Maybe it has a little bit. I think about the helmet and the Head and Neck Support (HANS) device and I think mine might not have been correctly adjusted for me. I didn't really hit my head in the accident; it was just a big stop. I was using a new HANS device that I hadn't used before and was also using a completely new seat. These things together maybe contributed to the problem and my head moved too much during the accident. It may have stopped my head too quickly and caused an injury.

> **"I THINK ABOUT THE HELMET AND THE HANS DEVICE AND I THINK MINE MIGHT NOT HAVE BEEN CORRECTLY ADJUSTED FOR ME."**

A+M: Do you think drivers could use better education on using safety equipment properly?

MG: Absolutely. We need more education because there is nothing wrong with having more information. That is always a positive. It only takes a few minutes out of your life and something can always be done on the safety front.

A+M: Are there any improvements that could be made in driver care, either post-accident or in the rehabilitation period?

MG: I don't really know the answer to that. You can always do something more in terms of safety and it is vitally important. I was not expecting to be involved in an accident like this and suddenly out of the blue I was injured.

A+M: What are your future plans?

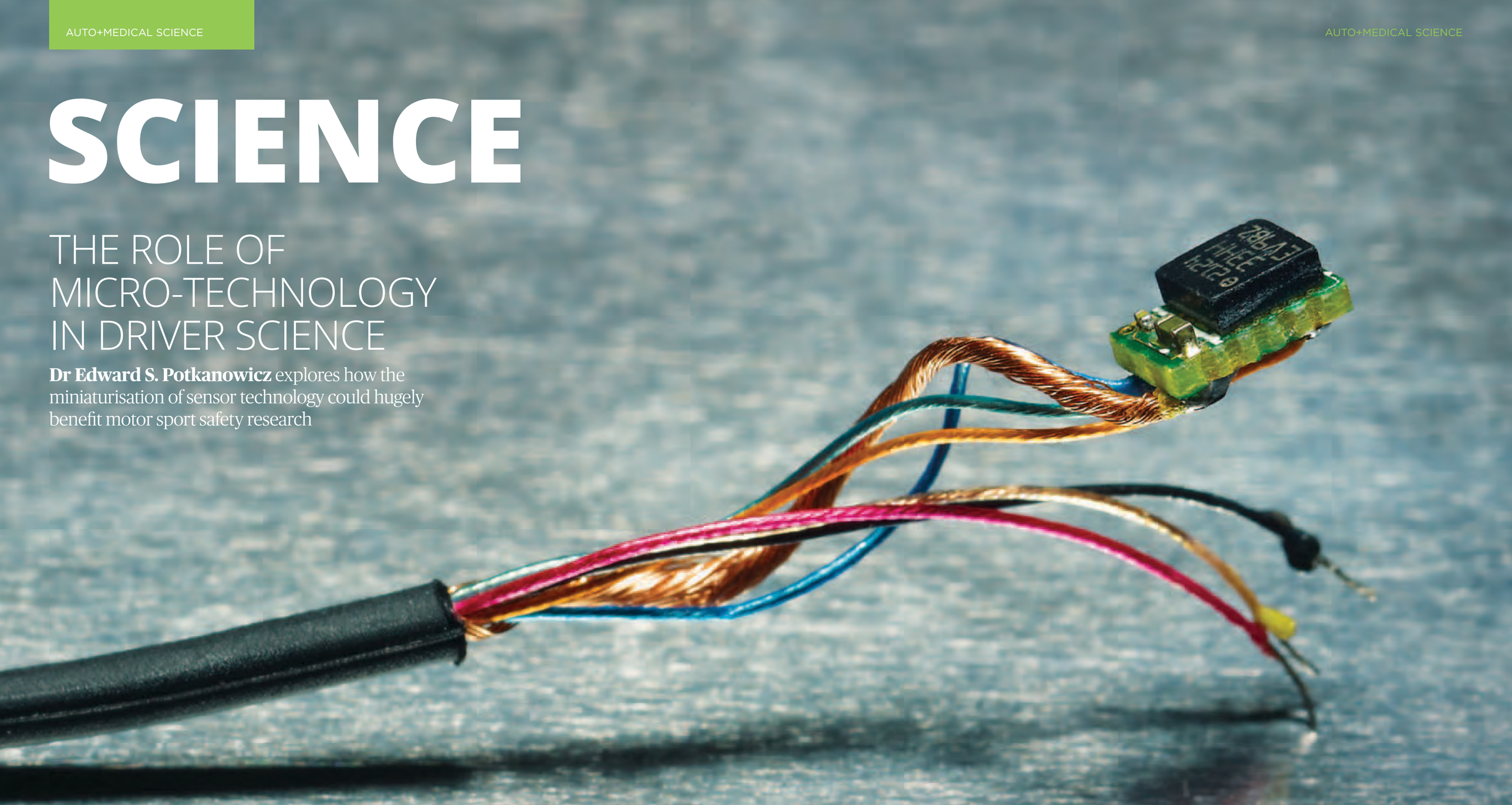
MG: For the moment I am doing some work for Volkswagen including testing. I have done some driver management work so I am still working in motor sport. But I have other business interests outside of the sport so I am happy. I have no plans to come back into competitive racing...for the moment at least.

AUTO+MEDICAL SCIENCE

SCIENCE

THE ROLE OF MICRO-TECHNOLOGY IN DRIVER SCIENCE

Dr Edward S. Potkanowicz explores how the miniaturisation of sensor technology could hugely benefit motor sport safety research



During an interview featured in the 2010 documentary film “Senna”, Sir Frank Williams, principal of Williams F1 Racing, said of Ayrton Senna[1]:

“Ayrton is arguably the best driver available, the best driver currently racing. The team is geared to being successful. All our partners, investors, sponsors expect that of us. And Ayrton is therefore the best piece of equipment, if you’d like, you could put in the machine to deliver to our requirement.”

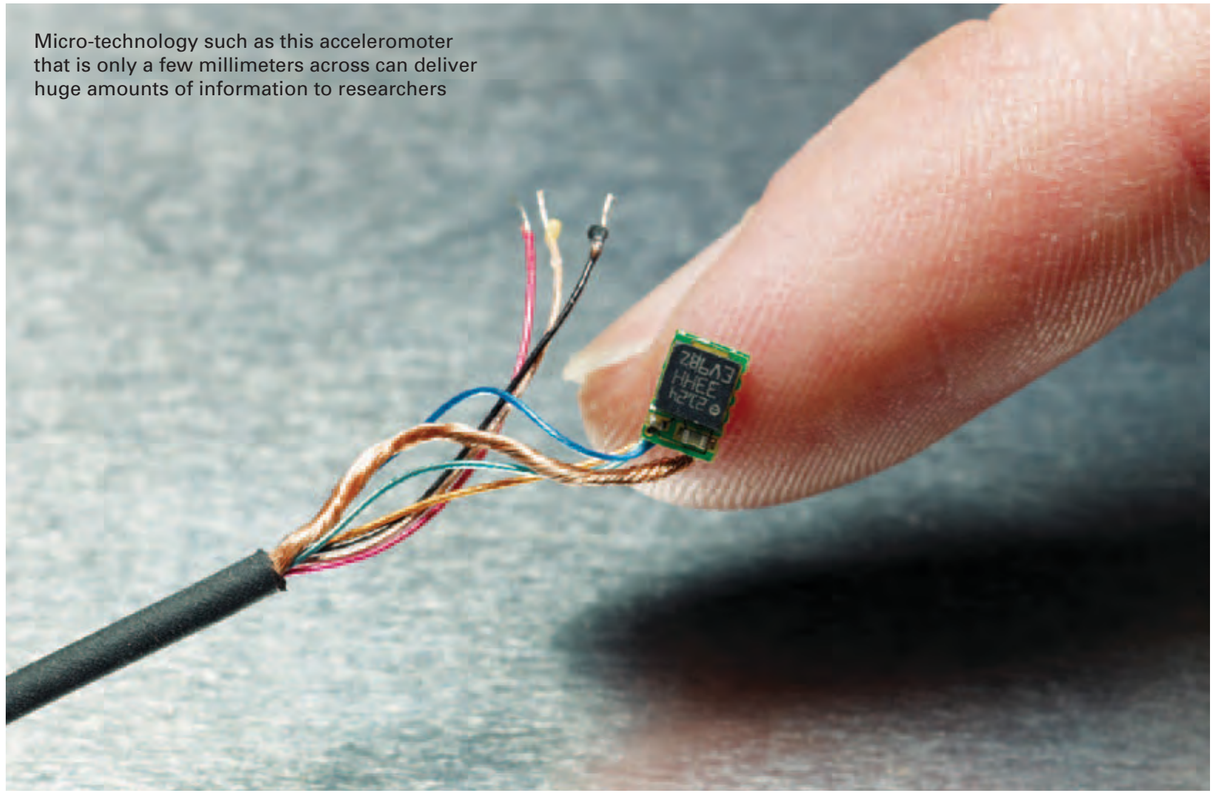
Once Senna slid into the cockpit of his Williams FW16, that “piece of equipment” became part of a system. Senna became one in a set of connected things forming a complex whole. However, in that cockpit, Senna, like numerous drivers before and after him, was the one thing that nobody knew anything about.

While the engineers could examine volumes of data relating to the car, little, if anything, was known about what the driver was experiencing. From a system perspective, only half of the system was being monitored. In addition, the one piece of equipment that controlled most, if not all, aspects of the system was left to its own devices to prepare for, and adapt to, its environment.

For all that the motorsports community has learned about the car, and for as far as the racecar has come from a design and development perspective, little attention has been paid to the racecar driver, the driver-athlete. But a new and exciting area of scientific investigation, called driver-science, is beginning to gain ground within the motor sport community and the scientists involved in this work are taking advantage of all that micro-technology has to offer and will bring to bear.

The term driver-science was first coined by Potkanowicz and Mendel[2] to describe this area of investigation. By definition, driver

Ayrton Senna chats to his engineer during Formula One pre-season testing in 1994



Micro-technology such as this acceleromoter that is only a few millimeters across can deliver huge amounts of information to researchers

science is the objective and scientific examination of the driver's physiological response to the environment of the cockpit, from which data-based recommendations can be made to improve driver safety, tolerance and performance.

Within traditional athlete ranks, objective and scientific assessment has been around for some time. This type of assessment has served the traditional athlete community well in that a full and comprehensive understanding of the stress of performance has been gained. As a result, sport specific recommendations for safe and effective training can be made in an attempt to improve the safety and performance of the athlete.

Comparatively, there is a paucity of information relating to the stress of driving a racecar and/or training recommendations for the driver-athlete. That which does exist lacks a similar foundation in data. But it is beginning to change.

Historically, efforts to assess the driver's response to the environment of the cockpit were met by great challenges. For example, the harsh environment of the cockpit (i.e. electro-magnetic interference, heat, or vibration), the lack of robustness of the equipment, size and weight concerns of testing equipment, and the element of safety all represented obstacles to overcome. For some time these obstacles were perceived as being insurmountable. Studies that did try to measure the driver's response were typically conducted during the off-season; used modified equipment; used measurement techniques that would not typically be approved by sanctioning bodies; or didn't actually look at the driver, but rather the car.[3, 4, 5, 6] As technology has progressed and equipment has become much smaller, these once insurmountable obstacles to driver-athlete monitoring are becoming less problematic. Advances in electronic shielding, the miniaturization of sensing and related equipment, and equipment that is more robust and stress tolerant have all contributed to the advancement of driver-athlete monitoring. With the development of new technology, speculation about driver stress can now be quantified.

From drivers' anecdotal reports and from the limited amount of work that does exist, our understanding of the stressors associated with driving include elevations in heart rate, muscular effort, thermal stress, and G-loading. Each of these represents an area where micro-technology may quantify what was previously only estimated or speculated. What follows is an examination of these known stressors, a look at the progress that micro-technology has made thus far, and a peek at where micro-technology may take motor sports' scientific community.

HEART RATE

Elevated and sustained heart rates are a hallmark response to physical activity. Motor sport is no different, as racecar drivers have demonstrated the same type of heart rate responses during practice and competition. Although one might think that the increase in heart rate is the result of a single influence (i.e. physical stress), a single source of the chronotropic increase has not been found. Rather, two primary factors are at play. The first is directly related to the physical work requirements necessary for competing in motor sport. The second factor is an increase in sympathetic nervous system output and the hormonal influences derived from the anxiety, anticipation and competitive nature of the sport.[6]

While increases in heart rate may be a hallmark response, what is perhaps more interesting is the interaction of heart rate with other physiological variables. For example, heart rate and exercise intensity share a proportional and linear relationship.[7] As exercise intensity increases, heart rate continues to increase in proportion to exercise demand until the exercise reaches maximal intensity. However, during times of persistent physical activity and heat stress, when the cardiovascular system is challenged to provide for both the exercising muscle and thermoregulation, there is a disproportional increase in heart rate even though there has been no increase in exercise intensity; this is known as cardiovascular drift.[7,8] Evidence of this response was noted as long ago as 1956 when Ladell and Watkins[9] noted an increase of 25 beats for every one-degree increase in body temperature. Should this condition persist, the athlete is at risk for the early onset of fatigue and eventual performance deficits.[10, 11, 12, 13]

A second example of this relationship between stressors is the impact of dehydration on cardiovascular function, and thus physical performance. Armstrong[14] offers that, regardless of the environmental temperature, acute dehydration reduces maximal oxygen uptake. Armstrong[14] also offers that the larger the fluid loss, the greater the loss in aerobic capacity. Greenleaf[15] suggests that body water losses equivalent to 4% of total body weight result in a 20-30% loss of physical work capacity. Examining the literature, it is not uncommon

to see fluid losses in drivers reported in the neighborhood of 1.0 liter per hour.[5, 16, 17]

From a functional perspective, this relates directly to a reduction in endurance capacity resulting from changes in cardiovascular function (e.g. increased heart rate and decreased cardiac output). In the end, while we know that a driver-athlete's heart rate increases in response to the stress of competitive driving, what is less well known is what happens to that same heart rate response after an extended duration race in the face of long standing hypohydration or dehydration. Also, while drivers may train aerobically in an effort to be a fit as possible, do the recommendations for aerobic training address the effect of the dehydration on heart rate response or the effect of thermal stress on heart rate response? Is there data to support those recommendations?

THERMAL STRESS

Speaking of thermal stress, let's take a moment and examine this particular stressor. The typical driver-athlete wears a multitude of safety garments. These would typically include a fire suit (one to three layers thick), fire resistant undergarments, a balaclava, fire resistant boots and gloves, and a helmet. As a result of these safety measures, what is left of the driver exposed to the environment is what the spectator sees peeking out of the visor. The driver then places him or herself into a vehicle, which has either little or no circulating air. The layers of protective clothing and the enclosure of the cockpit create numerous microenvironments, each compromising the driver's thermoregulatory ability.[4]

Adequate thermoregulation requires exposure to the environment and a gradient (i.e. either a dry heat exchange gradient or a water vapor pressure gradient). As was mentioned, the part of the driver's body that is exposed to the environment is not much more than his or her eyes, assuming the visor is up. This presents a problem. Although all of the safety equipment is necessary, under the physical stress of driving, it's not long before the driver finds him or herself subjected to a severe, and often an uncompensable, heat stress. Add to this the compounding impact of repeated muscular effort, excessive humidity, and dehydration and the problem is not only disconcerting, but also potentially dangerous.

Anecdotal evidence of this danger, at least for the driver, can be seen in the collapse of Formula One driver, Nigel Mansell, as he attempted to push his John Player Special Lotus across the finish line during the 1984 Dallas Grand Prix. Similarly in 1982, Nelson Piquet, having just won the Brazilian Grand Prix, passed out while standing on the podium.

In sport, the impact of excessive body temperature on human performance has been well documented and has been shown to have a number of negative outcomes.[14, 18, 19] In contrast, the effects of increased body temperature on the driver-athlete and performance are not as well documented. Although few empirical studies have actually examined this issue, some have mentioned the need for investigation. As far back as 1972, Falkner[20] questioned whether the issue of the cockpit environment and the hot conditions drivers are exposed to warrant further or new investigations. In 1987, Jareño et al.[21] wrote to the editor of the British Journal of Sports Medicine with the intention of alerting readers to the risk of thermal stress in motor-car prototype racing drivers. Concerned about the impact of heat stress, Rodrigues and Magalhães[22] investigated the role of hyperthermia in the 1994 death of

Nigel Mansell collapses after the 1984 Dallas Grand Prix

Ayrton Senna, but concluded that Senna's death was not the result of uncompensable heat stress.

Jacobs, Olvey, Johnson, and Cohn[4] suggested that given the environment that drivers perform in, the heat stress they are exposed to, and the likelihood of developing uncompensable heat stress, future research in this area is warranted. The authors go on to say that not only is there a paucity of "publicly available data regarding the professional racecar driver," but that the reason for this lack of scientific information is that much of it is never published by the independent laboratories, teams and/or consultants who conduct it.[4]

Regarding thermal stress, Wyon and Norin's[23] work documents the deterioration of hand-eye coordination in passenger car drivers with an increase in core body temperature as little as 0.8 C. The wheel of a current Formula One racecar may have as many as 35 multi-function buttons, switches, and knobs, as well as a multi-function LCD display. Clearly, given the thermal stress that drivers are regularly exposed to, clarity of thought and judgment, as well as response time and accuracy, are essential. The effect of increased driver body temperature on various aspects of performance seems like a worthy candidate for micro-technology and for further investigation.

Some within the scientific community have attempted to quantify the thermal stress experienced by the driver-athlete. Collins[24] was contracted by the National Aeronautics

AUTO+MEDICAL SCIENCE

Using simulated driving within an environmental chamber, researchers attempted to examine the impact of heat and carbon monoxide on driver performanceduring a NASCAR event.

and Space Administration to assess the physiologic responses of racecar drivers. Although body temperature was measured, it was not a main focus of the project and thus not reported in any meaningful detail.

Brearley and Finn[16] examined the thermal response of four V8 Supercar drivers during short- and long-course races. Using ingestible core probe technology, the authors reported an average post-race core temperature of 39°C (102.2°F). This was an increase from the average pre-race temperature of 37.7°C (99.86°F). Using simulated driving within an environmental chamber, Walker, Ackland, and Dawson[25] examined the impact of heat and carbon monoxide on driver performance. With the environmental chamber set to mimic a NASCAR event (i.e. 50°C ambient temperature and 10-12% carboxyhemoglobin levels), drivers demonstrated significantly greater sweat loss and core temperature change than when the driver was exposed to the heat-only environment.

As is evidenced by the three studies mentioned here, very little work has been done examining the thermal stress experienced by the driver. If similar studies have been conducted, they have not been published and/or made available to the scientific community. Further, when one considers the summative effects of dehydration, thermal stress and repeated muscular effort, the problem is not only disconcerting, but also potentially dangerous.

MUSCULAR EFFORT

Regarding muscular effort, there was a time when driving a racecar was not considered to be particularly “physical”.[20] That misconception is continually changing as more is learned about what exactly a driver does and experiences while in the car. He or she must repeatedly move a steering wheel that, in some cases, has no power steering. Regardless of the type of steering, the exhaustive repetitiveness of steering wheel input would be of particular interest in an investigation of the muscular efforts associated with driving a racecar. Beyond steering, the driver must operate the

pedals of the car, each of which has its own resistance and number of times that it is depressed in the course of a race. Add to these examples the repetitive G-loading (negative and positive) and the effort that the driver must put forth to maintain his or her position in the cockpit against that load. Simultaneously, he or she must work to keep the head, clad in a helmet with a combined head-helmet weight of approximately 6.5Kg, in the proper driving position.[26]

Evidence of this muscular effort can be found in the work of Jacobs, Olvey, Johnson, and Cohn[4]. In this study, the authors compared the physiological responses of drivers to road and oval courses. Their findings demonstrated higher oxygen consumption and heart rates during road course testing compared to an oval speedway, although the absolute driving speeds on the road course were slightly more than half of the speedway speeds. The authors speculated that, while there are potentially several different explanations for these responses, the primary explanation might be related to the muscular work differences. They suggest that the increase in oxygen consumption and heart rate reflects an increase in energy expenditure above baseline. The stable body position of the driver is established primarily by isometric contraction of the neck, abdomen and legs. Therefore, the increased energy requirements are most probably related to the increased muscular activation required to maintain the driver's position in the car.

Ebben and Suchomel[27] approached the topic of muscular effort from a more subjective perspective. The authors interviewed 40 stock car drivers from 27 different states in the U.S. in an effort to assess the physical demands, injuries, and conditioning practices. As it relates to muscular strength, the authors reported a significant negative correlation between "track points standings" and length of resistance training sessions. Additionally, the authors identified, via participant self-report, upper body strength as the most important physical demand. Additionally, participants in the study reported shoulder fatigue as the most common form of muscle soreness experienced after a race event. Speaking anecdotally, IndyCar driver Dario Franchitti related in a 2012 RoadandTrack.com interview how he asked his race engineers to quantify the muscular effort he puts forth during a race event.[28, 29, 30] Using the on-board data acquisition system, the engineers determined that during each of three major braking efforts at the Mid-Ohio Sports Car Course, Franchitti generated 1375 pounds per square inch of (brake) line pressure. When they factored in the motion ratio of his brake pedal, they were able to calculate that Franchitti was applying 135 pounds of force to the brake pedal each time.

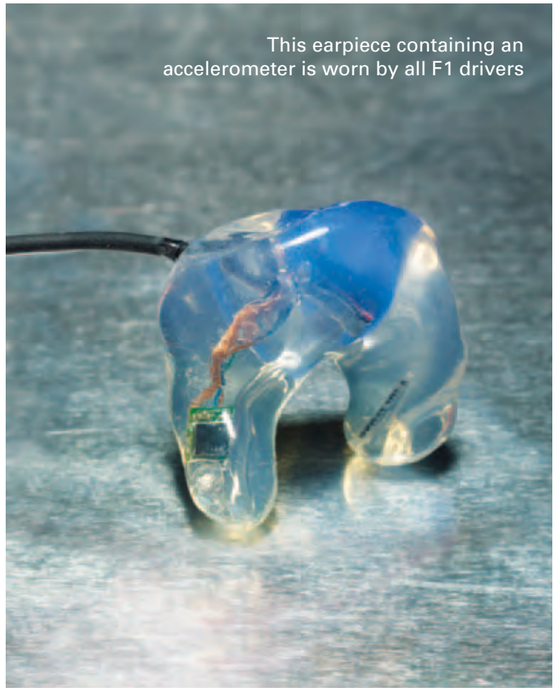
When the engineers examined the effort put forth by their driver to steer, they calculated an effort equivalent to 35 pounds of twisting force each time he turned the wheel. For the duration of the race, which includes 13 turns, the engineers reported that their driver would have done the equivalent of 1,105 repetitions. These studies, and the anecdotal reporting of RoadandTrack.com, represent the few that have addressed directly in the car, the role of muscular strength in motorsport. However, the act of driving is not the only place where and when a driver must exert muscular force. When one considers the amount of gravitational loading that a driver experiences in the course of an event and the work that must be done to counter it, muscular effort becomes a much more significant stressor to manage.

G-FORCE/LOADING

G-force represents the acceleration that a mass (in this case the driver-athlete) experiences in a given situation. This force can be both positive and negative and can occur about more than one axis (i.e. Gx [front-to-back], Gy [side-to-side], or Gz [head-to-toe]). Furthermore, G-Force can be a significant force to contend with from a human performance perspective. Former Formula One driver David Coulthard related it this way: "Your upper body must be strong enough to survive the stress of 5G, and when you brake at the end of the straight it feels like a sledgehammer has hit your back."[31]

There is scientific evidence of how much G-force the human body can tolerate. For example, when exposed to positive Gz forces, it becomes difficult to breathe as the lungs are pulled down and emptied of air.[32] Further, a greater cardiovascular effort must be put forth in order to pump blood to the brain. In the presence of positive Gz forces, blood is pulled away from the head, regardless of how hard the heart works.[32] Regarding circulatory issues, the eyes start having trouble from a circulatory and delivery perspective around 2-3G.[33] First, peripheral vision is lost, which creates the tunnel vision effect. If the condition persists, vision continues to degrade until it is lost completely and blackout occurs. Regardless of the environment or setting, persistent and excessive G-loading can be problematic from a performance perspective.

One of the best examples of science and micro-technology being used for the benefit of the driver-athlete revolves around G-forces and the cancellation of the 2001 Championship Auto Racing Teams (CART) Firestone Firehawk 600 at the Texas Motor Speedway. Following two unexplained crashes during practice and drivers reporting episodes of dizziness and vertigo, being sick to their stomachs, and being unable to stand after exiting the car following practice, the medical safety staff began to suspect that the drivers were experiencing symptoms of excessive G-loads.[34] Data pulled from driver Paul Tracy's in-car data acquisition system confirmed the suspicion and showed that Tracy had experienced in excess of 3.5 G's vertically and 5.5 G's laterally.[34] The discovery that the drivers were experiencing a combination of excessive vertical and lateral G-forces, and in the case of one driver, G-Induced Loss of Consciousness (G-Loc), CART determined that it was unsafe for the drivers to compete.[34] It was determined that the drivers were experiencing the very high combined G-loads because of their high on-track speed (all but two cars had average speeds of over 230mph in practice) and the



This earpiece containing an accelerometer is worn by all F1 drivers

banking of the speedway (24° in each of two turns).[34, 35] The decision to cancel the race was based on the empirical data from Tracy's in-car data acquisition system, but also from the anecdotal reports of drivers. This event and its outcome represent the value of empirically-derived data related to the driver and motorsport safety. But this event represents only the tip of the iceberg when it comes to what can be accomplished with micro-technology.

A WORLD WE HAVEN'T BEEN IN

Since that very brave decision, the motor-sport community has begun to take steps to integrate more monitoring and sensing into the driver-athlete community. For example, the tri-axial in-ear accelerometer, first used by the Indy Racing League and currently in testing with the FIA, represents only the beginning of all that can be accomplished and uncovered using micro-technology. As proof of this point, Andy Mellor, FIA Institute Research Consultant, speaking of the in-ear accelerometer, was quoted as saying "This knowledge will take us into a world we haven't been in".[36]

The in-ear accelerometer, manufactured for the FIA by STMicroelectronics, measures 3x3x1.0mm3 and is small enough to be nestled within the molded earpiece that the driver wears.[36] With the introduction of the in-ear accelerometer, crash data becomes immediately available in real time. Similar to the comments made earlier in this article, Mellor offers that while previously data relating to a shunt was more about the car, this new technology allows investigators to gather "precise kinematic data of the [driver's] head and the timing of the head movement during an accident".[36] Additionally, with quantified evidence of what a driver's head experiences during an event, scientists can work to make data-based improvements in chassis design, head-surrounds and improved driver positioning. However, the in-ear accelerometer represents only one of many new opportunities that the earpiece, as a micro-technology platform, can provide.

Relatively speaking, the earpiece that a driver currently wears has a fair amount of available space. This author's own research has focused on embedding micro-sensors in the driver's earpiece for the purpose of real-time physiological driver monitoring. Considering just how small sensing devices have become, this "extra space" represents an area where new and valuable sensors can be embedded for additional physiological monitoring.

The earpiece is a perfect platform for physiological monitoring for a number of reasons. First, the drivers are used to the earpiece and as such it doesn't interfere with their driving. Second, the earpiece doesn't compromise driver safety as other devices might. For example, when using something like an ingestible probe (i.e. a radio thermometer that the driver swallows), in the unfortunate even that a driver has a shunt, as per the instructions from the manufacturer, the driver cannot undergo a Magnetic Resonance Imaging Test (MRI).

This removes a valuable diagnostic tool from the toolkit of the track or emergency physicians. Similarly, to assess heart rate using a simple heart rate monitor worn around the chest, or to affix anything directly to the driver's body, would introduce an unnecessary burn risk in the event of a fire. Lastly, both of these examples often fail in their data acquisition because of the rugged electro-magnetic environment of today's cars. Using the earpiece as a platform overcomes

Using on-board data acquisition system, engineers determined that Dario Franchitti generated an effort equivalent to 35 pounds of twisting force each of the 1,105 times he turned the wheel at the Mid-Ohio Sports Car course.

each of these shortcomings and would provide a wealth of information.

Simple variables such as heart rate and body temperature could provide quantifiable information about the actual physical exertion and stress of driving. Mapping a driver's thermal or heart rate response, and creating thermal and cardiac signatures would provide not only basic physiological data but valuable derived data as well. For example, indices of physiological strain could be calculated from changes in heart rate and body temperature, the absence or presence of cardiovascular drift could be determined by examining the responses of heart rate and body temperature, and the onset of fatigue could be better predicted. However, the value of this data extends far beyond the racetrack.

Just as a driver uses a simulator for race preparation, physiological data gathered during actual race events could be replicated in the laboratory to provide sport specific training. Practicing in the simulator, and using real-time physiological data from the actual race event, a driver could be heated or cooled to the same level as what was experienced at that same event the previous year. Similarly, training interventions, both off-season and in-season, would become that much more specific and effective if based on actual race data. The change in the thermal and cardiac signature of any driver would be quantifiable evidence of the success of their training.

Beyond the obvious scientific value, real-time driver monitoring has emergency medical applicability as well. Similar to comments made by Andy Mellor relating to the medical usefulness of the accelerometer data in a crash, real-time physiological monitoring could provide the track physician with invaluable data about a driver, even before arriving on scene. These represent only a few of the directions that micro-technology can take the world of motorsport. Truth is, the future of micro-technology in motorsport is as varied as its changing driver demographic, which itself represents a new and exciting area of investigation.

Historically, racing has been populated by male drivers. However, in recent years, numerous series, both developmental and professional, have seen an increase in the number of female drivers. What little is known about the impact of the stressors on the male physiology is magnified when the discussion turns to the female driver. To not address gender-specific issues related to racing performance is to ignore a burgeoning driver-athlete population. Similarly, with drivers coming into developmental and professional series at younger ages and with drivers competing well into their 40's, and beyond in some series, examining issues related to the influence of age on driving performance would be of great value. Fundamental to these arguments, and to those presented earlier, is that understanding the stresses that the driver-athlete experiences makes a safer and better driver.

CONCLUSION

Many driver-athletes since Senna have commented anecdotally on the physical challenges of driving a racecar. Some have even expressed an interest in knowing just exactly what they're experiencing in the cockpit. Using the comparison of the driver as a piece of equipment, if the driver is to function at the highest level, then, as with any other piece of equipment, those who are responsible for the equipment need to know as much about it, and its variations, in order for it to function to its fullest. As such, given the advancements in micro-technology and given the opportunity to expand the knowledge base, the following recommendations are offered.

First, rather than examining a singular physiological variable, examine the interaction of variables. For example, measure the impact of increased body temperature on heart rate response. Second, examine variables that are more representative of the changing driver population. For example, examine gender- and age-related differences. Third, measure drivers in real-time during actual race events. For example, make physiological data available to the engineers that would tell them when the driver was likely to make a mistake because of fatigue.

Additionally, using the data gathered from races to develop laboratory-based simulations representative of the driver's actual physiological response rather than anecdotal reports. Lastly, work to develop data-based training programs for the preparation of drivers.

With the introduction of micro-technology into the assessment of the driver-athlete and a more public discussion and dissemination of information on the topic of driver science, the scientific community has the opportunity to quantify that which has been largely assumed and speculated upon. In uncovering this information, the scientific community has an opportunity to contribute to racing becoming that much safer, that much more competitive, and that much more comprehensive for the driver, the team, and the sport.

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AUTO+MEDICAL SCIENCE

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