

# The IOC Centres of Excellence bring prevention to Sports Medicine

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## ABSTRACT

The protection of an athlete's health and preventing injuries and illnesses in sport are top priorities for the IOC and its Medical Commission. The IOC therefore partners with selected research centres around the world and supports research in the field of sports medicine. This has enabled the IOC to develop an international network of expert scientists and clinicians in sports injury and disease prevention research. The IOC wants to promote injury and disease prevention and the improvement of physical health of the athlete by:

(1) establishing long-term research programmes on injury and disease prevention (including studies on basic epidemiology, risk factors, injury mechanisms and intervention), (2) fostering collaborative relationships with individuals, institutions and organisations to improve athletes' health, (3) implementing and collaborating with applied, ongoing and novel research and development within the framework and long-term strategy of the IOC and (4) setting up knowledge translation mechanisms to share scientific research results with the field throughout the Olympic Movement and sports community and converting these results into concrete actions to protect the health of the athletes. In 2009, the IOC also identified four research centres that had an established track record in research, educational and clinical activities to achieve these ambitions: (1) the Australian Centre for Research into Injury in Sport and its Prevention (ACRISP), Australia; (2) the Sport Injury Prevention Research Centre (SIPRC), Canada; (3) the Clinical Sport and Exercise Medicine Research (CSEM), South Africa and (4) the Oslo Sports Trauma Research Center (OSTRC), Norway. This paper highlights the work carried out by these four IOC Centres of Excellence over the past 6 years and their contribution to the world of sports medicine.

Sport and Exercise Medicine Research (CSEM), Cape Town, South Africa and (4) the Oslo Sports Trauma Research Center (OSTRC), Oslo, Norway. Under the Head of Scientific Activities, LE, the IOC wants to promote injury and disease prevention and the improvement of physical health of the athlete by:

- ▶ Establishing long-term research programmes on injury and disease prevention (including studies on basic epidemiology, risk factors, injury mechanisms and intervention).
- ▶ Fostering collaborative relationships with individuals, institutions and organisations to improve athletes' health.
- ▶ Implementing and collaborating with applied, ongoing and novel research and development within the framework and long-term strategy of the IOC.
- ▶ Setting up knowledge translation mechanisms to share scientific research results with the field throughout the Olympic Movement and sports community and to convert these results into concrete actions to protect the health of the athletes.

The IOC had supported these research centres with an annual grant. "A key part of the grant is meant to foster collaboration with the four centres internationally. The IOC wants to put a major thrust behind prevention of injury and the protection of the athlete's health. The annual funding is meant to be a catalyst" said LE from the IOC Medical Commission.

This issue of the *BJSM IPHP* highlights the work carried out by these four IOC Centres of Excellence over the past 6 years. In this paper, the leaders of each centre articulate the Centre's contribution to the world of sport medicine.

## IOC RESEARCH CENTRES OF EXCELLENCE

Since 2007, the IOC has developed a variety of programmes focused on prevention of injuries and illness as well as protection of the health of the elite and recreational athlete. One of these programmes is in your hands or on your screen/mobile device: the IOC supports four annual special editions of the *BJSM*, focusing on *Injury Prevention and Health Protection (BJSM IPHP)*.

In 2009, the IOC also identified four research centres that had an established track record in research, educational and clinical activities. Currently, four IOC Centres of Excellence are: (1) the Australian Centre for Research into Injury in Sport and its Prevention (ACRISP), Ballarat, Australia; (2) the Sport Injury Prevention Research Centre (SIPRC), Calgary, Canada; (3) the Clinical

## Australian Centre for Research into Injury in Sport and its Prevention (Australia)

ACRISP is a multidisciplinary and collaborative research centre covering disciplines as far ranging as behavioural science, biomechanics, biostatistics, health promotion, epidemiology, implementation science, public health, safety science, sports medicine, sports physiotherapy and sports science. It is directed by CFF and its other lead researchers JLC, Paul McCrory and Andrew McIntosh. The ACRISP team includes over 25 full-time researchers and/or clinician researchers who are either staff or students of Federation University Australia (FedUni) or appointed as FedUni Research Associates whose primary work is elsewhere (eg, at Monash University, the Australian Institute of Sport). The core ACRISP research team is supplemented with



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research associates who collaborate on specific research grants or PhD projects. Most of the ACRISP staff have salaries funded from externally generated research income. ACRISP currently has nine full-time PhD scholars.

#### The ACRISP research focus

Injury prevention is the science of quantifying the magnitude of, and reasons for, the health and social burdens associated with injury; and for developing and testing innovative solutions to address this global public health issue. The ACRISP research programme draws on its epidemiological, clinical, statistical and biomechanical strengths in this work. Safety promotion focuses on understanding individual/environmental/organisational barriers and motivators to the delivery and uptake of preventive measures; the research of ACRISP in this area draws on the team's behavioural psychology, clinical engagement, health promotion, implementation science and public health strengths. The major research areas of ACRISP are listed below.

#### *Sports injury surveillance, coding and classification systems*

High quality data are needed about sports injury occurrence and the risk/protective factors associated with its aetiology. This depends on robust methods to monitor injury incidence and to collect relevant exposure (ie, sports participation) with standardised definitions so that results can be compared and contrasted spatially (across regions and sports) and temporally (over time). Together with clinical colleagues, the ACRISP epidemiologists and biostatisticians are advancing the design of, and reporting from, sports injury surveillance systems; contributing to international efforts to improve the coding/classification of sports injuries; informing international consensus statements for sports injury surveillance; and providing guidance on the appropriate statistical analysis of injury data. The two ACRISP research papers in this issue of *BJSM IPHP* are key recent outputs from this work until now.<sup>1 2</sup>

The first paper from the ACRISP team in the current *BJSM* issue presents the Subsequent Injury Classification (SIC) model developed to categorise multiple, recurrent, exacerbation or new injuries in the context of acute and overuse injuries that makes provision for all potential within-person correlations.<sup>1</sup> Correct categorisation of subsequent injury of any type requires the input of significant clinical expertise, and the SIC model combines this expertise with more objective statistical criteria. This new way of classifying subsequent injuries includes, for the first time, explicit consideration of the possible relationships (correlations) between different injuries within an injured person. It has already started to be used with success by other groups, as shown by recent abstracts from the 2014 IOC Injury Prevention Conference in Monaco<sup>3 4</sup> and its inclusion in the new international Athletics injury definition consensus statement.<sup>5</sup>

The second paper from ACRISP in this issue gives an overview of the statistical issues that need to be considered when analysing subsequent injury data.<sup>2</sup> The paper compares different types of survival analysis models for subsequent event data through their application to prospectively collected professional rugby league injury data over one season. It shows how such models can be applied and explains why current common methods of analysis are inadequate for subsequent sports injury data.<sup>2</sup> Extension of this modelling approach to risk factor identification has been published elsewhere.<sup>6</sup>

Ongoing sports injury prevention research will be hampered if there is little application of the more sophisticated statistical models for modelling subsequent injury data. Moreover,

predictive or causal models to underpin sports-related musculoskeletal injury prevention strategies will be incorrect if they continue to ignore the inherent relationships between injuries or apply inadequate analysis methods. These two papers from ACRISP now set the basis and direction for future research in this important area.

#### *Prospective monitoring of sports injury incidence and injury causation*

Sports injury studies need to incorporate injury experiences over more than one season if they are to describe the incidence of subsequent injury accurately, as well as to document any non-acute adverse impacts they might have on health status, future injury risk and ongoing participation in sport. ACRISP's research is contributing to the design, validation and analysis of data from large-scale cohort studies to monitor injury experiences (including recurrences), the impacts of these injuries and sports participation on health (eg, need for joint replacement or reconstruction surgery, development of osteoarthritis, impact of overuse injuries, etc) and future sport participation (eg, time away from sport due to injury<sup>1 2 7</sup>). Further, its research combines these prospective studies with fundamental mechanistic and biomechanical studies to better understand the aetiology of injury and identification of suitable prevention measures. For example, ACRISP's research is contributing to improved diagnostic tools for tendinopathy,<sup>8</sup> and is also shaping clinical management and research into tendinopathy<sup>9</sup> and related musculoskeletal disorders.<sup>10</sup> Other research is providing new understanding into the biomechanics of injuries,<sup>11</sup> such as concussion and shoulder injury, is a prerequisite for developing effective equipment and methods to assess the equipment performance.<sup>12 13</sup>

#### *Intervention effectiveness, implementation, dissemination and sustainability*

Implementation research within community sport is critical because, even if interventions have been shown to be efficacious in controlled trials, if they cannot also be demonstrated to be widely adopted and sustained, then it is unlikely that they will have any preventive effect. There is very little information about how to translate research evidence into effective sports injury interventions and how to implement interventions in sport successfully.<sup>14</sup> ACRISP's research is leading international efforts to contribute new insights into the sports delivery settings and individual behaviour contexts in which interventions are to be implemented.<sup>15 16</sup> Our research has involved detailed investigations into the organisational, policy and individual behavioural barriers and enablers of evidence-based sports injury prevention interventions in sports settings.<sup>17 18</sup> Major work over the past 5 years has been the development, implementation and evaluation of the FootyFirst lower limb injury prevention programme and delivery plan for Australian Football nationally.<sup>19 20</sup> ACRISP's impact biomechanics research is showing how enhanced knowledge can lead to improved equipment standards, which are an important mechanism for translating the science of injury prevention into products bought off the shelf.<sup>21 22</sup>

#### Community engagement and leadership

ACRISP's research impacts on all those involved in sport and recreation, from the participants themselves (amateur, professional and recreational) through to those who support those participants (medical practitioners, clubs and sporting facilities, peak sports bodies, government agencies) at international, national, regional and local levels of participation.

Research leaders from ACRISP actively contribute to international sports injury management and prevention at the international level through chairing and/or membership of specific IOC Medical Commission Working Groups (eg, on Boxing); membership of expert panels for peak international sporting federations (eg, International Rugby Board); contributing to the development of international injury surveillance definitions and consensus statements; leading the development of international consensus statements on concussion in sport. Researchers from ACRISP are also frequently sought by national sports bodies and government departments to contribute to the development of sports safety policy, evaluation of injury prevention practices and/or to contribute new evidence to underpin such actions. In recent years, these actions within high-performance sport have been undertaken as collaborations with many International and National Sports Federations—the Australian Football League (AFL), National Rugby League, the Australian Rugby Union, Football Federation Australia, Volleyball Australia, Tennis Australia, Cricket Australia, the Australian Ballet, the Australian Racing Board, the Australian Institute of Sport. A major part of the ACRISP research programme is its translation of research evidence developed for elite/professional sport to the more community forms of sporting activity and this has been conducted in partnerships with the AFL, National Rugby League, Australian Rugby Union, Football Federation Australia as well as work with State and National Government Departments of Sport and Health.

#### ACRISP summary

The ACRISP research programme aims to specifically reduce the public health and sports performance/participation burdens of sports injury through the identification of the causes/mechanisms of the injury events, monitoring of the incidence of the short-term and long-term adverse outcomes of those injury events and evaluation of implemented strategies to prevent them. The ACRISP team is leading international research into the real-world implementation of sports injury interventions and their effectiveness, including identification of the best way/s to translate this knowledge to reach those who will most benefit from this research. In order to provide a strong basis for the evaluation of these impacts, ACRISP's research also contributes to new and rigorous methods for injury prevention research and the statistical analysis of injury data. Most importantly, the ACRISP research programme is innovative in that it is designed from the outset to have maximal impact on, and engagement with, the intended direct beneficiaries (ie, the sports participants themselves), the bodies that set and implement sports safety policy and practice (ie, government agencies, sports bodies), the sports safety workforce (ie, sports medicine practitioners, coaches and club-based staff) and the new generation of researchers keen to continue this work.

#### Sport Injury Prevention Research Centre (Canada)

WHM and CAE cochair the SIPRC in the Faculty of Kinesiology at the University of Calgary. SIPRC focuses primarily on research related to injury prevention in youth sport and recreation. It is an interdisciplinary research team including research collaborators and community partners provincially, nationally and internationally. Emery, Meeuwisse and colleagues have led the development and execution of several interdisciplinary teams including the Alberta Innovates Health Solutions funded team 'Alberta Program in Youth Sport & Recreational Injury Prevention' (2013–2018), the Canadian Institutes of Health Research funded team 'Mild Traumatic Brain Injury in

Children and Youth: Best Practices in Early Diagnosis and Management' (2013–2018) and the Canadian Institutes of Health Research funded programme 'Consequences of knee joint injury in youth sport: Implications for knee osteoarthritis and other health outcomes' (2014–2017). SIPRC contributes to both the International Olympic Committee and International Paralympic Committee Injury Surveillance Research Programmes (Vancouver 2010, London 2012 and Sochi 2014).

#### The SIPRC research focus

The priorities of SIPRC have been driven by the potential public health impact of evidence informed practice and policy to reduce the burden of youth sport and recreational injury. There are two highlights where health and policy relevant priority areas have had informed substantive public health impact.

#### *Concussion and injury in youth ice hockey*

Ice hockey is one of Canada's most popular sports with >25% of male youth participating. It is also one of the highest injury producing sports in youth. Concussion has been a matter of increasing concern in leagues where body checking is permitted.<sup>23–25</sup> SIPRC's most significant research contributions are highlighted by a 10-year programme of research in youth ice hockey that has informed policy change. Research findings demonstrated that policy allowing body checking in Pee Wee ice hockey (ages 11–12) leads to a 3–4-fold greater risk of injury and concussion compared to leagues where body checking is not allowed.<sup>26</sup> Further, body checking experience at younger ages does not decrease the risk of all injury and concussion in older (ages 13–14) players.<sup>27</sup> This landmark research programme evaluating body checking policy and risk factors for injury and concussion in youth ice hockey has led initially to provincial (2011) and subsequently to national policy change delaying body checking in youth ice hockey from age 11 to 13 in the USA (2011) and then in Canada (2013). This policy change has had a large public health impact in reducing the burden of concussion and injury in youth ice hockey. Elimination of body checking in 11–12-year-old leagues is expected to translate to over 1300 injuries prevented in the province of Alberta annually (400 concussions). The estimated direct medical cost savings nationally exceed \$C 2,000 000 annually in this age group alone. Further research will inform future policy change in older age groups (ages 13–17) in non-elite levels of play. Programmatic research evaluating concussion prevention and management strategies in youth sport is a key SIPRC priority. The youth ice hockey research programme also includes examination of preseason evaluation tools in youth ice hockey players (eg, neurocognitive, clinical, functional, sport-specific performance and neuroimaging) in the identification of risk factors for concussion and predictors of longer term sequelae following concussion.<sup>28–32</sup> The SIPRC team has evaluated the efficacy of vestibular and cervical physiotherapy following concussion that has informed concussion management practice.<sup>33</sup>

#### *Injury prevention to prevent osteoarthritis*

The efficacy of the neuromuscular training injury prevention programme has consistently demonstrated a reduction in the risk of youth soccer and basketball injuries by more than 30%.<sup>34 35</sup> Ongoing collaborations with several national and international research groups will focus on the development and evaluation of such programmes in other youth community sports (eg, rugby and football). The development and evaluation of a physical education curriculum-based high-intensity neuromuscular training

prevention strategy suggests a reduction in sport and recreational injury risk by >50% as well as a reduction in adiposity in junior high school students (ages 11–15).<sup>36</sup> Behaviour change and long-term maintenance of such programmes are an ongoing focus of inquiry. Based on previous youth RCTs and cohort studies (n>8000), SIPRC has developed a unique longitudinal cohort examining the long-term consequences of joint injury in youth, including post-traumatic osteoarthritis (PTOA).<sup>37</sup> Outcomes include physical activity participation, adiposity, functional outcomes, biomechanics, biomarkers and MRI hypothesised to be associated with PTOA in young people with a history of knee injury. This research will inform the development of secondary prevention strategies to delay the onset and progression of PTOA. In partnership with community stakeholders (Alberta Health Services Strategic Clinical Network and Bone and Joint Canada), SIPRC researchers are leading the development of provincial and national strategies in the prevention of injury and PTOA.

#### Community engagement and leadership

The priority of the SIPRC team includes building research capacity provincially, nationally and internationally in injury prevention in child and adolescent sport and recreation to inform community sport, school board and health practice and policy. Ongoing partnerships with the community and government have informed relevant knowledge synthesis, dissemination, exchange and application. These partnerships have been key to successful implementation of prevention programmes in the community and have facilitated greater public health impact. Ongoing collaboration with community stakeholders across several diverse sectors (Canadian Paediatric Society, Canadian Academy of Sport Medicine, Canadian Physiotherapy Association, sport governing bodies (FIFA, IOC, International Paralympic Committee (IPC), Hockey Calgary, Hockey Edmonton, Hockey Alberta, Hockey Quebec, Hockey BC, Hockey Canada, Calgary Minor Soccer, Calgary School Boards), not-for-profit organisations (Parachute, Sandbox Project, Bone & Joint Canada) and legislative/policy groups (Alberta Health and Wellness)) has informed optimal evidence-informed practice and policy change.

#### SIPRC summary

It is estimated that the impact of the evidence and translation to public health policy and practice will lead to a 20% reduction in injury burden in youth sport and recreation in the province of Alberta by 2020. SIPRC continues to build research and trainee development capacity in injury prevention in youth sport and recreation to promote active health and enhance personal health and well-being in our youth population. The practice and policy implications of the SIPRC research programme until now have been a substantial public health impact in reducing the risk of injury in sport and recreation in youth in Canada. This research is relevant to policymakers across healthcare, education and public health priorities. With appropriate knowledge translation strategies and evaluation, this work will inform best practice across health services and systems, education, community sport and public health sectors. A shift in focus from disease management to injury and chronic disease prevention is critical to the future health of our population.

#### Clinical Sport and Exercise Medicine Research (South Africa)

MS, together with WD, directs the CSEM group in the Department of Human Biology, Faculty of Health Sciences at the University of Cape Town in South Africa. Their research group focuses primarily on research activities related to protection of the health of athletes as defined in its broad application

of illness prevention (primary prevention), management (secondary prevention) and rehabilitation (tertiary prevention). This also includes the promotion of a healthy lifestyle (including physical activity) in the population at large—a vision that is shared by the IOC. In addition, this group focuses research on injury prevention in specific athlete groups and sports.

#### The CSEM research focus

In the past 6 years, the research highlights from this group were in the following main areas: (1) identification of the burden of illness and injury in specific populations of athletes, (2) protection of the health of athletes participating in mass community-based endurance sports events and (3) development and implementation of a comprehensive lifestyle intervention programme for patients with lifestyle-related chronic diseases.

#### *The burden of illness and injury in specific populations of athletes*

The group developed a web-based electronic injury and illness surveillance programme (WEB-IISS), which was based on the studies the group conducted together with FIFA–Medical Assessment Research Center (F-MARC) during the 2009 Confederations Cup football tournament,<sup>38</sup> and the 2010 FIFA World Cup in South Africa.<sup>39</sup> As part of these early studies, an illness surveillance system was developed and this provided novel data on illness in football players. The full WEB-IISS, including illness and injury surveillance, was then applied during the 2012 London Paralympic Games,<sup>40–42</sup> and again in the 2014 Sochi Winter Paralympic Games. These studies were conducted in collaboration with the IPC medical committee. The novel data derived from these studies now form the basis of an ongoing longitudinal injury and illness surveillance programme in athletes with disabilities—an area that has received very little attention in the sport and exercise medicine literature until now. Several illness and injury prevention strategies can now be identified and their impact can be assessed in future studies.

This group also developed a similar electronic illness and injury surveillance system for team sports participating in tournaments.<sup>43</sup> Illness data during a 16-week rugby union tournament showed a high incidence of illness during international travel.<sup>44</sup> These data have a much wider application for athletes from other sports codes that travel across multiple time zones to compete in international tournaments. Once again, these baseline data now form the basis for implementing prevention strategies to reduce the burden of illness resulting from international travel. Similarly, data reported in this edition indicates a high risk of injury during the 16-week rugby union tournament.<sup>45</sup> Once again, injury prevention strategies can now be introduced and the impact of these can be evaluated in future studies.

#### *Protection of the health of the athlete participating in mass community-based endurance sports events*

It is well recognised that physical activity is an important component of a healthy lifestyle to prevent and manage non-communicable chronic disease. However, it is also well recognised that participation in moderate to strenuous physical activity can be associated with an increased risk of sudden cardiac death and other life-threatening medical complications, particularly in endurance sports. In this regard, the CSEM group focused a substantial component of its research activity on strategies to reduce adverse medical events in the exerciser (SAFER studies). Several research studies have been concluded over the past 6 years in runners participating in a 21 km and a 56 km endurance event—the Two Oceans marathon races. In these studies, a higher rate of medical complications was

identified, serious life-threatening medical complications were documented<sup>46</sup> and several risk factors for medical complications were ascertained.<sup>47–48</sup> As a result of these data, an online medical screening tool and educational intervention programme was developed to reduce the risk of medical complications in these recreational athletes. Finally, an extensive medical and injury history database in over 45 000 recreational runners has been compiled. These data form the basis of a prospective cohort study to identify risk factors for medical complications and injury in this group.

#### *Development and implementation of a comprehensive lifestyle intervention programme for patients with lifestyle-related chronic diseases*

The global health and economic burden of lifestyle-related chronic diseases are well established. Therefore, lifestyle intervention programmes aimed at the primary, secondary and tertiary (rehabilitation) level are imperative to reduce this burden. The IOC has recognised this, and actively promotes physical activity and lifestyle intervention in all population groups. Recently, there has been a call for the Sport and Exercise Medicine physician to play an active role in providing a clinical service that focuses on lifestyle intervention for chronic disease. Members of this research group have developed such a programme for patients with established chronic disease. This programme is both patient-centred (not disease-centred) and comprehensive (not single intervention). In this *BJSM IPHP* edition, this programme is described and the preliminary results are presented.<sup>49</sup>

#### **CSEM summary**

The research activities in this group have had a significantly wider impact and some of the highlights are as follows: Real time (daily) illness and injury monitoring using the WEB-ISS was conducted during the 2014 Sochi Winter Paralympic Games. A wider translation of this methodology is possible in other game settings, and there has been interest from other tournament organisations to use the same methodology. Novel findings on injuries in athletes with impairments have received attention from manufacturers of prosthetics and other protective equipment. Equipment to reduce injury risk can be developed and tested. The greater awareness of illness in rugby tournaments has resulted in the implementation of illness prevention strategies, particularly while travelling across many time zones. This information has also been of interest to sports other than rugby, where travelling is an integral part of the competition. In the Two Oceans Marathon races, the medical screening and educational intervention programme is now compulsory for all the runners entering the races.

#### **Oslo Sports Trauma Research Center (Norway)**

RB and LE have led the development of the Oslo Sports Trauma Research Center (OSTRC) since 2000, when the Center was established at the Norwegian School of Sport Sciences as a research collaboration between the Department of Orthopaedic Surgery, Oslo University Hospital and the Norwegian School of Sport Sciences. Initially, the OSTRC was based on grants from the Royal Norwegian Ministry of Culture, the Norwegian Olympic and Paralympic Committee and Confederation of Sports and Pfizer AS. Since 2005, the activity has been expanded based on grants from the Eastern Norway Regional Health Authority, FIFA, the IOC and FIS.

The Oslo Sports Trauma Research Center has a multidisciplinary team which does translational research. The OSTRC has at any time 15–20 PhD students, part-time or full-time, with a multidisciplinary background, involved in different research

projects. The core research team consists of physicians, physical therapists and sport scientists recruited from the Oslo University Hospital and the Department of Sports Medicine at the Norwegian School of Sport Sciences, but involves scientists and clinicians with a multidisciplinary background from several different hospitals and laboratories nationally and internationally.

#### **The OSTRC research focus**

The main objective of the OSTRC has been to develop a long-term research programme on sports injury prevention (including studies on epidemiology, risk factors, injury mechanisms and interventions studies). The programme focuses mainly on three sports (football, team handball and alpine skiing/snowboarding), as these account for more than 50% of all sports-related injuries treated in Norwegian hospitals. Aims also include the most common (eg, ankle and hamstrings) and the most serious (eg, ACL and concussions) injuries seen in these sports. Recently, the Center's aims have been expanded to studies in the prevention of other health issues such as eating disorders, the female athlete triad and sudden cardiac death. In addition to injury prevention research, the cartilage and ligament research group has focused on surgical and non-surgical treatment options to prevent future damage to an injured joint (ie, osteoarthritis).

#### *The burden of injury and other health issues in specific athlete populations*

The OSTRC has completed a number of cohort studies to describe the magnitude of the problem in their targeted sports as well as among elite athletes, recreational athletes and in youth and children's sport. Thus, there is a lot of data on the incidence, patterns and severity of acute time-loss injuries across most sports and levels of participation. The OSTRC has established key surveillance systems to monitor the rate of specific injury types or in specific sports, such as the Norwegian National Cruciate Ligament Register,<sup>50</sup> the FIS Injury Surveillance System<sup>51</sup> and the National Football Injury Surveillance System.<sup>52</sup> These systems monitor changes in injury patterns over time. However, overuse injuries have largely been neglected so far, and although a consensus was reached on how to record and report data in epidemiological studies on injuries, the OSTRC has recently shown that this standard methodology does not capture overuse injuries. Overuse injuries may represent as much of a problem as do acute injuries in many sports,<sup>53</sup> and this is the case not just among elite athletes but also among recreational athletes, runners and other 'weekend warriors'. As a first step, the OSTRC has therefore developed and now validated new methods to quantify overuse injuries, taking advantage of new digital technology to record data directly from the athlete. These studies include a selection of team sports and endurance sports at different levels of participation. The second step is to employ this novel methodology to conduct prospective studies to measure the magnitude of key overuse problems in selected sports and at the same time study their risk factors.<sup>54–55</sup> Such studies are ongoing, using handball, where shoulder problems and low back pain are prevalent, as a model. Also, a new PhD project on the young elite athlete has just started to monitor load and the risk of developing health issues over time.

#### *Risk factors and mechanisms*

The second step in the sequence of injury prevention is to map the causes of injuries, to identify their risk factors and mechanisms. The OSTRC has developed new research models and methods to describe and understand the inciting event, the mechanisms of injury, based on video recordings of actual

injuries. Injury mechanisms among elite athletes are often the same as in recreational or youth sports and our approach takes advantage of the fact that in elite sports, injury mechanisms are often captured in detail by TV recordings. The OSTRC is the only research centre in the world systematically applying video analysis methods with novel model-based image-matching technology (POSER method) to a range of sports including handball, football, alpine skiing and snowboarding.<sup>56 57</sup> This provides more precise descriptions of the mechanisms of sports injuries, for example, for knee injuries, than has previously been possible. The POSER method is now being used in a number of studies across different injury types and sports, and the OSTRC recently published the most compelling data that exist to explain the specific biomechanical underpinning of ACL injury in team sports and alpine skiing.<sup>58 59</sup>

#### *Injury prevention and implementation*

The final steps in injury prevention research are to introduce measures that are likely to reduce the future risk and/or severity of sports injuries and document whether they are effective, preferably by means of a randomised controlled trial. The Oslo Sports Trauma Research Center has completed six large-scale landmark studies in the field: a case-control study on helmet use in recreational snowboarders and alpine skiers,<sup>60</sup> an intervention study on a balance training programme to prevent ACL injuries among female senior handball players,<sup>61</sup> a randomised controlled trial on an exercise programme to prevent lower extremity injuries in youth handball players,<sup>62</sup> an intervention study using a novel eccentric strength exercise programme to prevent hamstring strains in male football players,<sup>63</sup> and two randomised controlled trials to develop a warm-up programme to prevent injuries among youth female football players.<sup>64 65</sup> A general finding across most of these studies is that injury risk can be reduced by as much as 50% through such simple measures. Similarly, a recently published 10-year study on knowledge translation and implementation in Norwegian elite handball could reveal a sustained 50% reduction in ACL injury risk in Norwegian elite level handball.<sup>66</sup>

#### *Dissemination of knowledge into practice*

The OSTRC is using a number of outlets to disseminate evidence-based information and programmes to prevent, treat and rehabilitate musculoskeletal problems and other health issues. The strong track record in knowledge translation includes the bilingual website <http://www.klokeavskade.no> (<http://www.ostrc.no> for English). This website is mainly directed at health-care professionals and researchers to inform them about the research activities at the Center, ongoing projects and their results, but also includes functionality to reach the media. The OSTRC promotes the website and other OSTRC discoveries and programmes actively using blogs, social media (Facebook—‘Senter for idrettsskadeforskning’, Twitter—‘@ostrc1’, other emerging channels). The OSTRC is working closely together with the national sporting governing bodies on the establishment of injury prevention in the education of coaches at all levels.

A new mobile application, Get Set, was recently created on the occasion of the 2014 Youth Olympic Games in Nanjing, China through collaboration between the IOC, the OSTRC, technology partners and several international sports federations. The target group is not only young talents and their coaches, but anyone engaged in physical activity. Get Set was created to help prevent sports injuries by providing the most effective and evidence-based workout routines.

#### *OSTRC summary*

The OSTRC has established key surveillance systems to monitor the rate of specific injury types or in specific sports. A novel methodology to reliably collect data on overuse health issues has been developed and employed in different studies. The Center’s research focus has been expanded to the protection of other athlete health issues, than injuries alone, such as sudden cardiac rest and eating disorders. The OSTRC is the only research centre systematically applying video analysis methods with novel model-based image-matching technology (POSER method) to a range of sports to better understand the injury mechanisms and thereby optimise injury prevention programmes. The results of effective injury prevention programmes are disseminated through an established outreach practice, involving various multimedia channels.

#### *Trainee environment in the four IOC Centres of Excellence*

The strength of the four IOC Research Centres ACRISP (Melbourne, Australia), SIPRC (Calgary, Canada), CESM (Cape Town, South Africa) and OSTRC (Oslo, Norway) leaderships is that they have remained committed to excellence in research training that maximises opportunities for all trainees, including undergraduate students, MSc students, medical students, PhD students, postdoctoral fellows and clinician scientists in sports medicine and sport science. All Centres provide students with a diversity of training opportunities to foster growth in methodological, clinical and applied research training. The ongoing dedication of trainees to research in injury prevention in recreational and elite sport following their training is a testament to the growing and sustainable programme of research in the field.

**Competing interests** None.

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