The studies presented in this thesis were performed at FINA events, McMaster University, Hamilton Canada and the Department of Public and Occupational Health and the EMGO+ institute for Health and Care Research at the VU University Medical Center, Amsterdam, the Netherlands.

ISBN:

Printing: Ipskamp Drukkers

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The role of International Sports Federations in safeguarding the health and well-being of athletes:
Lessons learned from FINA’s activities

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad Doctor aan
de Vrije Universiteit Amsterdam,
op gezag van de rector magnificus
prof.dr. F.A. van der Duyn Schouten,
in het openbaar te verdedigen
ten overstaan van de promotiecommissie
van de Faculteit der Geneeskunde
op dinsdag 17 November 2015 om 9.45 uur
in de aula van de universiteit,
De Boelelaan 1105

doors
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CHAPTER 1

General Introduction
INTRODUCTION

As 70% of the world is covered in water, man has enjoyed the benefits of swimming for centuries. Swimming as a global sport is enjoyed by individuals around world of all ages with varying levels of skill and participation ranging from the basic ‘learn to swim’ participant to the Olympic level elite athlete. Swimming is a physical activity that prevents death from drowning and promotes physical fitness with numerous physical and psychological health benefits \(^1\)–\(^3\).

FINA, the International Federation that governs the modern sport of aquatics, was founded in 1908. Swimming was one of the original sports in the 1\(^{st}\) modern Olympic Games in 1896. Currently FINA has 204 member National Federations representing all five continents. FINA governs the rules and regulations of six competitive disciplines including swimming, diving, water polo, synchronized swimming, open water swimming and high diving. In addition, FINA is responsible for developing and implementing the competitive program for these disciplines at the Olympic Games, FINA World Championships and FINA World Cup events throughout the competitive calendar. Aquatic Continental Organizations and National Federations are also governed by the FINA rules and regulations.

As a member of the Olympic Movement, FINA is governed by the Fundamental Principles and Regulations outlined in the Olympic Charter. According to the Olympic Charter, all International Federations have, amongst others, an obligation \(^4\):

- to encourage and support measures protecting the health of athletes
- to encourage and support the development of sport for all

The protection of the health of the athlete is outlined in the Olympic Movement Medical Code \(^5\) which governs the actions of the medical committees of the International Sports Federations:

“\textit{The Olympic Movement, in accomplishing its mission, should encourage all stakeholders to take measures to ensure that sport is practised without danger to the health of the athletes ... it encourages those measures necessary to protect the health of participants and to minimise the risks of physical injury and psychological harm.}”
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The principles outlined in the Olympic Charter and the Olympic Movement Medical Code form the premise of this thesis. Based on these guiding principles, all International Federations are obligated to protect the health and well-being of athletes who compete in their sports. FINA, as a member of the Olympic Movement, is also obligated to protect the health of its athletes. In the FINA Medical Rules, a provision for this responsibility exists:

“FINA, in accomplishing its mission, should take care that sport is practised without danger to the health of the athletes .... To that end, it takes the measures necessary to preserve the health of athletes and to minimise the risks of physical injury and psychological harm.”

In addition, in response to the health risks of sport participation, Fuller and Drawer published a theoretical framework to conceptualize risk management in sport. They conclude that International Federations have a duty to identify health risks inherent to participation in their respective sports and to respond to these risks through the designing and implementation of prevention programs to mitigate these health risks.

The purpose of this thesis is to examine the activities of FINA, as an International Sports Federation, in safeguarding the health and wellbeing of the athlete and the global community. This thesis outlines the steps taken by FINA to meet the obligation to protect the health of the aquatic athlete.

A FRAMEWORK FOR THE PROTECTION OF ATHLETES’ HEALTH

Understanding the injury and illness risks of a sport requires application of an evidence-based systematic approach. Only by accurately defining the problem can effective prevention measures be implemented and evaluated. As per van Mechelen et al., the problem first must be identified and described in terms of incidence and severity. Then the factors and mechanisms that play a part in the occurrence of sports injuries have to be identified. The third step is to introduce measures that are likely to reduce the risk and/or severity of the identified problem. Such
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measures should be based on the etiologic factors and the mechanisms as identified in the second step. Finally, the effect of the measures must be evaluated by repeating the first step, which will lead to so-called time-trend analysis of injury patterns. However, from an epidemiological standpoint it is preferable to evaluate the effect of preventive measures by means of a randomised controlled trial (RCT)\textsuperscript{8}. In further clarification of Step 2 of the injury prevention sequence, Meeuwisse identifies more factors to be considered including intrinsic risk factors inherent to the athlete and exposure to extrinsic risk factors (Figure 1)\textsuperscript{9,10}.

![Figure 1](image)

**Figure 1** A dynamic recursive model of injury aetiology. Adapted from Meeuwisse\textsuperscript{9,10}.

**KNOWLEDGE GAPS IN AQUATIC ATHLETE HEALTH**
As outlined by the injury prevention sequence, prevention starts with an identification of the problem in terms of magnitude and severity. In other words, one can only effectively make a difference through prevention (policy) when one knows what problems to tackle and prevent. In practice, one may come across a plethora of ideas and statements in regards to aquatic athlete health, e.g. swimming is sport with little risk for injury; swimming induces asthma; etc. Such statements are predominantly based on opinion rather than objective data, and a lot of knowledge gaps appear to exist.

**Injury and illness risk in the aquatic disciplines**

With respect to the problem definition in the aquatic sports the majority of available information stems from the IOC registry of injuries and illnesses during the Olympic Games\(^{11-13}\). Comparing water polo with other team sports during the 2004 Olympic Games in Athens revealed that water polo was safer than most other team sports, ranking sixth out of eight for the relative risk of injury. The total injury incidence was 12 injuries per 1,000 player matches \(^{11}\). Another study analysing trends in water polo injuries during the time period between 2004 and 2009 showed that the overall injury incidence remained steady; however, significant gender differences were found \(^{12}\). A study looking at injury incidence in all of the aquatic disciplines in the 2008 Olympic Games in Beijing also showed that the aquatic sports had a low incidence of new-onset injury relative to the other summer aquatic disciplines. In particular, in comparison with the overall injury incidence rate of 9.6% for the Games, the incidence rates for the aquatic sports were: swimming (3.4%), diving (2.1%), and synchronized swimming (1.9%). Water polo (9.7%) had one of the highest rates of in-competition injury. Swimming, however, did show a high incidence of training and overuse injuries \(^{13}\). Besides these Olympic Games data, there are no publications on injury and illness surveillance in the elite aquatic sports. With respect to Step 2 of the injury prevention sequence, there were no reported studies looking at aetiology of injury or illness in the aquatic disciplines.
To address the knowledge gaps identified above and to fulfil the first step in the injury prevention sequence, Chapter 2 of this thesis describes a prospective cohort study recording newly incurred injuries and illnesses during the FINA World Championships. This Chapter determines the health and safety of the elite aquatic athlete during the in-competition time period.

As the aquatic athlete spends more time in training in comparison to competing, to gain a better understanding of athlete health, it is imperative to also look at injury and illness surveillance during the non-competitive training period. No systematic prospective studies are published on injuries and illnesses encountered during the training period in the elite aquatic athlete population. There is one prospective study monitoring shoulder pain in Australian swimmers\(^\text{14}\) and one descriptive retrospective epidemiological study in collegiate swimming in the USA\(^\text{15}\). As such, in response to this knowledge gap, a study was conducted to assess the health of the aquatic athlete in the non-competition period. Chapter 3 examines the health of the aquatic athlete in the training period leading into the World Championships. The retrospective survey component of this study provides insight into the problems encountered in the aquatic athlete caused by training in addition to providing more data on in-competition injuries and illnesses. Given the identified knowledge gaps with respect to the need to more accurately define the problem of injury and illness incidence and severity in the aquatic sports, attention in this thesis is devoted to Step 1 of the injury prevention sequence.

**Aquatic sports and asthma**

Investigation of the literature revealed information on a health risk inherent to the aquatic sports\(^\text{16}\). Respiratory and family physicians have prescribed swimming as a recommended form of physical activity for asthmatics for many years, as swimming is considered to be less asthmagenic\(^\text{17,18}\). However, evidence exists which implicates the aquatic environment itself as a cause of asthma through exposure of the airways to allergens, particulate matter and irritants such as pool chloramines\(^\text{19}\). Although there are studies published on asthma in swimmers\(^\text{20-23}\) there are no studies published on asthma in elite swimmers. There is one study on asthma in adolescent
National-level water polo players but no publications on the other aquatic disciplines. To mitigate this knowledge gap, a study on asthma prevalence in elite aquatic athletes was conducted. Chapter 4 presents a large cohort study over an extended period of time comparing the prevalence of asthma in the aquatic disciplines and other Olympic sports.

The issue of relative energy deficiency in sport

In the disciplines of synchronized swimming and diving, there is a sport related risk of the female athlete triad (i.e. Triad) given the esthetic nature of these judged sports, which for some athletes results in the voluntary restriction of energy intake to achieve desirable body composition. However, the female athletes in the aquatic endurance disciplines of middle and long distance swimming – both in the pool and in the open water - are also vulnerable to low energy availability (LEA), which is the underpinning cause of the Triad. In contrast, the LEA in these athletes is due to high levels of energy expenditure from training relative to their energy intake rather than due to a restricted intake of energy as is more often seen in the esthetic aquatic disciplines. The swimmer also has the added challenge that swim velocity is inversely correlated with active drag; i.e. the greater the drag, the slower the swim. At the elite level, training goals are focused on improving stroke efficiency and attaining an ideal body composition to decrease drag. Therefore, four of the five aquatic disciplines, (synchronized swimming, diving, swimming and open water swimming) have significant risk for LEA and potentially the Triad.

But what about the male athlete? There are no studies published on the effects of LEA in the male aquatic athlete. The performance of male athletes in swimming and open water swimming is also affected by active drag and male divers and synchronized swimmers are also vulnerable to body image issues common to judged sports. Chapters 5 through 7 investigate the health and performance issues related to energy availability and the effect of LEA on health and performance. An innovative and critical view of the current literature is presented to broaden the definition and to expand the concept of the ‘Triad’ to ‘Relative Energy Deficiency in Sport’
(i.e, RED-S). A clinical assessment tool is introduced to facilitate the management of this syndrome for the team physician.

**A ROLE FOR INTERNATIONAL FEDERATIONS IN PUBLIC HEALTH?**

Morbidity and mortality from preventable, non-communicable chronic disease (NCD) threatens both global population and economic health. The WHO has classified insufficient physical activity (PA) as the fourth leading independent risk factor for the development of NCDs after hypertension, tobacco use and elevated blood glucose. Insufficient PA is associated with a myriad of health consequences in both children and adults including obesity, cardiovascular disease, diabetes mellitus, pulmonary diseases, musculoskeletal diseases, cancer and depression.

Sport as the gatekeeper to physical activity has the ability to participate in the prevention of the epidemic of NCDs. In their article entitled ‘Achieving the Millennium Development Goals’, the United Nations Inter-Agency Task Force on Sport for Development and Peace, reinforces the importance of sport in the prevention of non-communicable diseases:

“Participation in sport has significant physical benefits, contributing to people’s ability to lead long and healthy lives, improving well-being, extending life expectancy and reducing the likelihood of several major non-communicable diseases.”

In 2010, the WHO and the IOC signed a memorandum of understanding to jointly address initiatives to reduce the risk of NCD (IOC 2011). The IOC President identified the role of sport in the battle against NCD in an address to the United Nations:

“The problem is acute, the solution is at hand. It is a grim picture, except for one thing: We can do something about it.”

With this precedence set, a review of the literature to determine the beliefs and activities of FINA and other International Federations in the field of athlete and global health protection revealed limited to no data. In response to this knowledge gap, a study was conducted to determine the
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priorities and actions of FINA and other International Federations of the Olympic Movement with respect to athlete health promotion in their elite athlete populations, recreational athletes and in the general population. Chapter 8 is a critical analysis of FINA’s role in health promotion in the elite aquatic athlete as well as its role in global health promotion. FINA’s priorities and activities in this domain are compared with other Olympic International Federations.

To conclude the thesis, Chapter 9 contains a general discussion of the study methods and the outcomes of the studies conducted and reported in Chapters 2 through 8. In addition, there is a summary of the implications of the findings with respect to the FINA’s objective of preserving and promoting elite aquatic athlete health. Finally, recommendations are made for future application of the study findings in the FINA program as well as the identification of further research needs.
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CHAPTER 2

Sports Injuries & Illnesses in the 2009 FINA World Championships (Aquatics)

ABSTRACT

**Background** Analysis of injury and illness prevalence in elite sport provides the basis for the development of prevention programs.

**Objectives** To analyze the frequency and characteristics of injuries and illnesses occurring during the 13th FINA World Championships 2009.

**Design** Prospective recording of newly incurred injuries and illnesses.

**Methods** The 13th FINA World Championships hosted 2592 athletes from 172 countries in the disciplines of swimming, diving, synchronized swimming water polo and open water swimming. All team physicians or physiotherapists were asked to complete daily a standardized reporting form for all newly incurred injuries and illnesses for their teams. To cover teams without medical staff, the physicians of the local organizing committee also submitted daily report forms.

**Results** 171 injuries were reported resulting in an incidence of 66.0 per 1000 registered athletes. The most affected body parts were the shoulder (n=25; 14.6%), and head (n=21; 12.3%). Half of the injuries occurred during training. The most common cause of injury was overuse (n=61; 37.5%). 184 illnesses were reported resulting in an incidence of 71.0 per 1000 registered athletes. The respiratory tract was most commonly affected (n=91; 50.3%) and the most frequently classified cause was infection (n=81; 49.2%). The incidence of injuries and illnesses varied substantially amongst the five disciplines with the highest incidence of injury in diving and the lowest in swimming.

**Conclusions** As the risk of injury varied with the discipline, preventive measures should be discipline specific and focused on minimizing the potential for overuse. As most of the illnesses were caused by infection of the respiratory and gastro-intestinal tract, preventive interventions should focus on eliminating common modes of transmission.
INTRODUCTION

Aquatic sports are enjoyed around the world from the recreational level to the elite level. FINA (Federation Internationale de Natation), which was founded in 1908, was one of the original sports in the modern Olympic Games with the inclusion of swimming in 1896. FINA has global representation with a total of 202 member National Federations. FINA has organized multidisciplinary aquatic World Championships since 1973 which are now held biannually. The 13th FINA World Championships held in Rome in 2009 was the largest aquatic event in the world with 2592 athletes participating from 172 countries.

Injury surveillance during elite events is a duty of care to ensure safety for future athletes. FINA is increasingly emphasizing the protection of the health of the athlete. FINA Medical Rules: Preamble Item 1.0: “FINA, in accomplishing its mission, should take care that sport is practised without danger to the health of the athletes ... To that end, it takes the measures necessary to preserve the health of athletes and to minimise the risks of physical injury.”

Although the aquatic sports enjoy worldwide participation, little is known of the incidence of injury for its participants at the elite level. Injury surveillance studies have been conducted in single sport events including football, rugby, handball, athletics, karate, ice hockey, volleyball, beach volleyball, cycling, and tennis. Injury surveillance studies have occurred in large multisport events at the 2004 Athens Olympic Games for team sports and for all sports at the 2008 Beijing Olympic Games. To the authors’ knowledge, no studies have been published on injuries incurred during major events in elite aquatics. One prospective five-year study on NCAA collegiate swimmers has been published in the scientific literature on injury incidence. Injury prevalence in aquatic sports is published from the 2008 Beijing Olympic Games and for water polo in 2004 Athens Olympic Games.

Although there are a limited number of publications on illness surveillance data at elite multisport events, aquatic specific illness incidence does not exist. Based on a previously standardized injury reporting system by the Federation International de Football Association (FIFA) in football, the IOC implemented an injury surveillance program during the 2004 Athens...
Olympic Games for team sports \(^2\) and the 2008 Beijing Olympic Games for all sports. In follow-up of the 2008 Beijing Olympic Games, the IOC decided to add illness surveillance for the 2010 Vancouver Winter Olympic Games. FINA conducted this current study to establish the feasibility of illness surveillance component as a pilot project for the 2010 Vancouver Winter Olympic Games.

The objectives of the current study were to record and analyze injuries and illnesses incurred during the 13\(^{th}\) FINA World Championships 2009.

**METHODS**

**Implementation**

In this study, the IOC Injury Surveillance system \(^3\) was implemented with the extension to also survey illness. All five disciplines of the 13\(^{th}\) FINA World Championships 2009 (swimming, water polo, diving, synchronized swimming, open water swimming) were included as the study population. In preparation for the study, an information booklet was circulated one month in advance to the medical representatives of all participating countries. A site visit occurred one month prior to the event by a member of the study group (MM) to educate the medical team of the Local Organizing Committee (LOC) on the logistics of the study. On-site in Rome, a voluntary information meeting was held for the medical teams of the visiting countries two days prior to the commencement of the Championships. These information sessions included instructions on completion and submission of the Reporting Forms. Instructional booklets and Reporting Forms were distributed. The team physicians, or in their absence, a team physiotherapist were asked to daily report on the occurrence (or non-occurrence) of all newly incurred injuries and illnesses. Reporting Forms could be submitted at a confidential mailbox adjacent to swimming pools. Reporting Forms were also accepted by fax and by electronic submission. Additional reporting forms were completed daily by the LOC medical team from each of the medical stations at the venues. Compliance was encouraged by regular visits to the national federation and LOC medical staff by members of the FINA Sports Medicine Committee.

**Definitions of Injury and Illness**
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The definition of injury was the same definition as used in the IOC Injury Surveillance system \(^\text{32}\), thus allowing comparison with previous studies \(^\text{26, 27}\). An injury was defined as any musculoskeletal complaint and/or concussion newly incurred due to competition and/or training during the 13\(^{th}\) FINA World Championships that received medical attention regardless of the consequences with respect to absence from competition and/or training. Pre-existing injuries were not included unless there was an acute exacerbation during the time period of the Championships. Injuries occurring not during training or competition were also excluded.

The definition of an illness was developed based on the injury definition to ensure compatibility with the existing injury protocol and ease of understanding for the participating physicians. An illness was defined as any physical complaint (not related to injury) newly incurred during the 13th FINA World Championships that received medical attention regardless of the consequences with respect to absence from competition or training. Chronic pre-existing illnesses were not included unless there was an exacerbation requiring medical attention during the Championships.

**Injury and Illness Report Form**

The injury part of the report form was identical in design to the IOC Injury Surveillance System utilized during the 2008 Beijing Olympic Games \(^\text{27, 32}\). The following information was required for documentation: athlete’s accreditation number, sport/event, heat/training, date and time of injury, injured body part/side, type and cause of injury, and estimated duration of the subsequent absence from competition and/or training. The illness part of the report form was located directly below the injury part on the same page. The following information was required for documentation: athlete’s accreditation number, sport/event, diagnosis, date, main symptoms, cause of illness, and estimated duration of the subsequent absence from competition and/or training. Definitions of injury and illness parameters were stated on the back of the form. Examples of injuries and illnesses to be included on the report form were illustrated in the Instructional Booklet. The injury and illness report form was available in five languages (English, French, Spanish, Italian, and Russian).
Confidentiality & Ethical Approval

Completed injury and illness report forms were stored during the Championships in a locked storage cabinet. The accreditation number of the athlete was used to ensure that duplication of reporting was avoided from the team doctor and the LOC physicians, and to facilitate the determination of age and gender of the athlete from the FINA database. After the Championships, the forms were made anonymous to ensure that no individual athlete or National Federation could be identified. Ethical approval was obtained from the Ethical Committee of the Oslo University School of Medicine.

Data analysis

All data were processed using Excel and SPSS. Response rate, coverage and incidences were calculated in accordance with the IOC approach for injury surveillance. Statistical methods applied were descriptive statistics, frequencies and cross-tabulations. For incidence rates, 95% confidence intervals (CIs) were calculated as the incidence 6 1.96 times the incidence divided by the square root of the number of injuries.

RESULTS

Response rate and coverage

A total of 2592 athletes from 173 registered countries participated in the 13th FINA World Championships. The medical staff from 73 countries (42.2%) with a total of 1745 athletes (67.3%) participated in the project and returned at least one report form, resulting in a total of 495 report forms. Since some countries did not compete in all five disciplines of the FINA World Championships, response rates were calculated separately (see Table 1).

The response rate and coverage of athletes by team physician’s reports were highest for water polo (53.4%) and lowest for swimming (21.8%).
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Table 1: Characteristics and team physicians’ response rates for the five aquatics disciplines

<table>
<thead>
<tr>
<th></th>
<th>Swimming</th>
<th>Open Water Swimming</th>
<th>Diving</th>
<th>Synchronized Swimming</th>
<th>Water Polo</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of athletes</td>
<td>1502*</td>
<td>155*</td>
<td>200</td>
<td>281</td>
<td>461</td>
</tr>
<tr>
<td>No of countries</td>
<td>170</td>
<td>41</td>
<td>42</td>
<td>41</td>
<td>21</td>
</tr>
<tr>
<td>Days of competition</td>
<td>8</td>
<td>5</td>
<td>9</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>26.7 - 2.8</td>
<td>19. - 25.7</td>
<td>17. - 25.7</td>
<td>18. - 25.7</td>
<td>19.7 -1.8</td>
</tr>
<tr>
<td>No of returned report forms</td>
<td>296</td>
<td>73</td>
<td>141</td>
<td>126</td>
<td>157</td>
</tr>
<tr>
<td>Response rate</td>
<td>21.8%</td>
<td>35.6%</td>
<td>37.3%</td>
<td>38.4%</td>
<td>53.4%</td>
</tr>
<tr>
<td>Coverage of athletes by team physicians</td>
<td>41.1%</td>
<td>56.5%</td>
<td>52.7%</td>
<td>53.1%</td>
<td>56.7%</td>
</tr>
</tbody>
</table>

* 7 athletes registered for Swimming and Open Water Swimming

Acute injuries and illnesses were reported daily by the physicians at the medical stations at the different venues. The majority of injuries (140; 82.5%) were reported by the team physicians; 32 (17.5 %) injuries were reported by the LOC physicians. Only one injury was reported by both sources. About three quarters of the illnesses (n= 133, 72.3%) were reported only by the team physician, one quarter (n= 41, 22.3%) only from venues, and ten (5.4%) by both sources.

Frequency and characteristics of injury

There were 171 newly incurred acute injuries reported during the Championships; equivalent to an injury rate of 65.6/1000 athletes. Female athletes had a higher risk of injury (n=88; 68.4 per 1000 athletes CI95% 54.1 – 82.7) than male athletes (n=68; 52.1 per 1000 athletes CI95% 39.7 –
64.5). The oldest injured athlete was 37 years old, the youngest 14 (in 57 cases age was missing). Most injuries affected the upper extremity (n= 63; 36.8%), followed by the lower extremity (n= 47; 27.5%), head/neck (n= 33; 19.3%) and trunk (n= 28; 16.4%). The most frequently injured body parts were the shoulder (n=25; 14.6%), and head (n=21; 12.3%). The most common types of injury were sprains (n=41; 24.0%) and skin lesions (n=32; 18.7%) (see Table 2).

Table 2: Number and diagnosis of all (time-loss) injuries in the championship and in the 5 disciplines

<table>
<thead>
<tr>
<th>Location and diagnosis</th>
<th>total</th>
<th>Swimming</th>
<th>Open Water</th>
<th>Diving</th>
<th>Synchronized Swimming</th>
<th>Water Polo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head / face</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>concussion</td>
<td>16 (3)</td>
<td>5 (1)</td>
<td>1 (*)</td>
<td>0</td>
<td>1 (0)</td>
<td>9 (2)</td>
</tr>
<tr>
<td>sprain</td>
<td>2 (2)</td>
<td>1 (1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1 (1)</td>
</tr>
<tr>
<td>contusion</td>
<td>2 (0)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2 (0)</td>
</tr>
<tr>
<td>skin lesion</td>
<td>4 (1*)</td>
<td>1 (0)</td>
<td>1 (*)</td>
<td>-</td>
<td>1 (0)</td>
<td>1 (0)</td>
</tr>
<tr>
<td>others</td>
<td>4 (0)</td>
<td>3 (0)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4 (1)</td>
</tr>
<tr>
<td>Cervical spine / neck</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sprain / strain</td>
<td>10 (1)</td>
<td>3 (1)</td>
<td>0</td>
<td>3 (0)</td>
<td>2 (0)</td>
<td>2 (0)</td>
</tr>
<tr>
<td>muscle cramps</td>
<td>5 (0)</td>
<td>2 (0)</td>
<td>3 (0)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>others</td>
<td>3 (1)</td>
<td>1 (1)</td>
<td>-</td>
<td>-</td>
<td>2 (0)</td>
<td>2 (0)</td>
</tr>
<tr>
<td>Lumbar spine / low back</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sprain / strain</td>
<td>15 (2)</td>
<td>5 (2)</td>
<td>0</td>
<td>5 (0)</td>
<td>0</td>
<td>5 (0)</td>
</tr>
<tr>
<td>muscle cramps</td>
<td>7 (0)</td>
<td>3 (0)</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>enthesopathy / fasciitis</td>
<td>6 (0)</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Other trunk</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>thoracic spine</td>
<td>8 (1)</td>
<td>2 (0)</td>
<td>0</td>
<td>0</td>
<td>2 (0)</td>
<td>4 (1)</td>
</tr>
<tr>
<td>sternum / rips / chest muscles</td>
<td>4 (1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4 (1)</td>
</tr>
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Location and diagnosis | total | Swimming | Open Water | Diving | Synchronized Swimming | Water Polo |
The role of International Sports Federations in safeguarding the health and well-being of athletes

Lessons learned from FINA’s activities

<table>
<thead>
<tr>
<th>Location and diagnosis</th>
<th>total</th>
<th>Swimming</th>
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</tr>
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</tbody>
</table>

*Note: The numbers in parentheses indicate the count of injuries, and those preceded by an asterisk (*) indicate a specific condition or injury type.*
### Chapter 2. Sports Injuries & Illnesses in the 2009 FINA World Aquatic Championship

<table>
<thead>
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<th>Ankle / foot</th>
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<td>-</td>
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<td>-</td>
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<tr>
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<td>-</td>
<td>1 (1)</td>
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<td>thor. + lumb. spine - muscl. spasm</td>
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<td>thigh + lower leg – skin lesion</td>
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<td>head + shoulder - skin lesion</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>head + arm / hand – skin lesion</td>
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<td>-</td>
<td>2 (0)</td>
<td>-</td>
<td>-</td>
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<tr>
<td>multiple – skin lesion</td>
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<td>1 (0)</td>
<td>-</td>
<td>-</td>
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</tr>
</tbody>
</table>

| missing information              | 6 (0)* | 0     | 5 (0)* | 0     | 1 (0) | 0     |

* Information on time-loss is missing in at least one injury; # Information on sport is missing in one case

Approximately half of the injuries (n= 79; 49.7%) were incurred during training or in competition (n=78; 49.1%), two injuries during warm-up for competition (in 12 cases the information was missing). On average, 7.2 in-competition injuries per 1000 starting athletes were reported. In most cases, the injury was caused by overuse (n=61; 37.5%). Other frequent causes of injury were non-contact trauma (n=25; 15.3%) and contact with another athlete (n=24; 14.7%).

Only 21 of the reported injuries (13.4%, 14 missing values) resulted in time-loss, which is equivalent to an 8.1 time-loss injury per 1000 registered athletes or less than 1% of the registered athletes. The five most severe injuries (estimated absence >=14 days) were a shoulder sprain, a
ligamentous rupture in the thoracic spine, a patellar subluxation, a tendon rupture in the hand and a broken finger.

The general injury risk was highest for diving (134.1/1000 female athletes) and lowest for swimming (21.8/1000 female athletes), the risk of an in-competition injury was highest in open water swimming (57.7/1000 starts of female athletes) and water polo (23.8/1000 starts of male athletes). There were no time-loss injuries incurred in women’s open water swimming and women’s diving. Injuries expecting a time-loss of greater than 14 days occurred in male water polo, swimming and in male open water swimming (see Table 3). While in swimming, synchronized swimming and diving most injuries were incurred during training, in open water swimming, synchronized swimming and water polo the majority of injuries occurred during competitions.
Table 3. Injuries and illnesses occurring during training and competition including time-loss from sport at the FINA World Aquatic Championships.

<table>
<thead>
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<th>Swimming¹</th>
<th>Open water swimming²</th>
<th>Diving</th>
<th>Synchro</th>
<th>Water polo</th>
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<td>Women</td>
<td>Men</td>
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<td></td>
<td>630</td>
<td>872</td>
<td>74</td>
<td>81</td>
<td>82</td>
<td>118</td>
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<td>2967</td>
<td>104</td>
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<td>1325</td>
<td>1866</td>
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<td><strong>Acute injuriesᵇ</strong></td>
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<td>19</td>
<td>7</td>
<td>8</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Injuries per 1000</td>
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<td>21.8</td>
<td>94.6</td>
<td>98.8</td>
<td>134.1</td>
<td>118.6</td>
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<td>0</td>
<td>1</td>
<td>8</td>
<td>9</td>
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<td>6</td>
<td>6</td>
<td>7</td>
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</tr>
<tr>
<td>Injuries per 1000</td>
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<td>2.02</td>
<td>57.7</td>
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<td>&gt; 14 days</td>
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<td>53</td>
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</table>

¹ 6 female and one male athletes participated in swimming and open water swimming
ᵇ sex missing in 18 injuries and 28 illnesses, 'time loss is missing in 14 injuries and 7 illnesses

**Frequency and characteristics of illness**

A total of 184 acute illnesses were reported, which is equivalent to 7.1% of the registered athletes suffering an illness during the Championships. About half of the illnesses affected the respiratory system (n= 91; 50.3%) and a fifth the gastro-intestinal system (n= 36; 19.9%). The most commonly reported symptom was pain. The most frequent diagnosis affected the upper respiratory tract including “otitis” (n= 31; 16.8%) and “tonsillitis” (n= 18; 9.8%). Consequently, the cause was most frequently classified as infection (n= 89; 49.2%) or environmental (n=50; 27.6%).

Thirty (16.3%) of the illnesses were expected to result in time-loss from sport inferring that only 1.2% of all registered athletes incurred a time-loss illness. However, time-loss illnesses were only reported from swimmers and male water polo players (see Table 3). No illness was expected to result in absence from sport longer than a week.

**DISCUSSION**

The aim of this study was to register and analyze all newly incurred injuries and illnesses in athletes participating in the 13th FINA World Championships 2009. To the authors’ knowledge,
this is the first injury and illness survey during an international aquatic event. The results indicate that the surveillance system was feasible and accepted by both the team physicians and the local medical staff. In all disciplines (except swimming) over 50% of all athletes were covered by the team physicians’ reports. Although medical reports were also received from LOC medical team at the medical stations at each competitive and training venues, the incidence of injuries and illnesses may be under-estimated due to the response rate indicated above. On average, less than seven percent of all registered athletes incurred injuries during the Championships. This injury rate is consistent with the injury incidence in aquatics reported during the 2008 Beijing Olympic Games (4.25%) \(^{27}\). The incidence of acute injury in swimming during the World Championships was substantially lower than in a five-year longitudinal study in NCAA Division I Colleges in the United States (4/1000 exposures) \(^{28}\), which includes chronic injuries in addition to acute new onset injuries.

Most injuries incurred during the FINA World Aquatic Championships affected the upper extremity followed by the lower extremity, trunk and head/neck. The most frequently injured body regions were the shoulder, low back and head. These findings are consistent with other published data in swimming where the shoulder was the most affected joint. \(^{31, 33-36}\) These findings differ however from the 2008 Olympic Games where about half of the injuries affected the lower extremity \(^{27}\) and the 2007 IAAF World Championships where 80% of all injuries affected the lower extremity \(^{16}\). This discrepancy is not surprising given the obvious differences in biomechanics between swimming and athletic disciplines. The injury location data obtained in this study illustrate the need in aquatic sport to focus injury prevention programs on the shoulder.

In most cases, overuse injuries were reported as the cause of injury (37.5%). Other causes identified were non-contact trauma (15.3%) and contact with another athlete (14.7%). All five time-loss injuries in water polo were caused by contact with another player, while seven time-loss injuries in swimming were caused by overuse and the other five by non-contact trauma. Attention to the prevention of overuse injuries should be a focus of aquatic injury prevention programs.
In the present study the proportion of in-competition injuries (50%) was lower than in team sports during the 2004 Olympic Games (75%) \(^{26}\), in athletics during the 2007 IAAF World Championships (74%) \(^{16}\) and all sports during the 2008 Olympic Games (75%) \(^{27}\). Only 21 injuries (13.4%) reported in the present study were expected to result in time-loss from sport. This proportion is substantially lower than reported from the 2008 Olympic Games (49.6% \(^{27}\)), the 2007 Athletics World Championships (56% \(^{16}\)) and the recent FIFA World Cups\(^{TM}\) (63-67% \(^{8}\). The data from the present study indicate that on average, less than 1% of the registered athletes incurred a time-loss injury during the FINA World Championships 2009. Even if this result may be an underestimation due to the moderate response rate, these data would suggest a relative low risk of serious time-loss injury in aquatic sports in comparison with other sports.

During the FINA World Championships in Rome 2009 slightly more illnesses than injuries were reported. These data contrast with the findings at the 1996 Olympic Games where more athletes were treated for injury (52%) than for illness (43%) \(^{31}\). The overall rate of illness from the Rome data was 7.1% of registered athletes. Approximately half of the illnesses reported affected the respiratory system. These findings are consistent with prevalence data from other elite sporting events such as the Olympic Games in 1996 \(^{31}, 2000^{28}\), and 2004 \(^{30}\). Results published from a prospective analysis of upper respiratory tract infections (URI) in athletes during training and in-competition shows that URI are more common in elite athletes than in non-competitive athletes \(^{37}\). This is thought to be due to the increased risk of infection from such factors as over training-induced “immuno-suppression” and from crowding at competition venues \(^{38}\). This is supported by the data from Rome where the highest incidence of illness was reported in swimming with the highest number of competitors exposed to more crowding in warm-up areas and event call rooms. The most frequent diagnosis of illness was otitis (n=31). Beck \(^{38}\) reports that ear infections are common in aquatic sports relating to exposure to water borne pathogens. No illness was expected to result in absence from sport longer than one week. Very few illnesses were related to exercise induced causes or environmental causes. This is in contrast to the data reported in the literature on other elite sporting events such as marathon running \(^{39}\).
At future FINA World Championships, attention to strategies to encourage compliance with reporting will improve the quality of the injury and illness surveillance program. The institution of injury prevention programs based on the findings from this study will be implemented and evaluated at future FINA World Championships.

CONCLUSION

The injury and illness surveillance system was accepted by the majority of the medical personnel at the 13\textsuperscript{th} FINA World Championships demonstrating its feasibility for any large international multidisciplinary event. Attention to improving compliance in reporting at future FINA World Championships will strengthen the quality of the results. The findings are consistent with studies in other sports using a similar methodology. Less than seven percent of the registered athletes were injured during the Championships with most injuries caused by overuse. The most commonly affected body part was the upper extremity. The incidence and characteristics of injury varied by discipline, with the lowest injury risk in swimming and the highest in water polo and open water swimming. Approximately seven percent of all registered athletes suffered an illness during the Championships with about half affecting the respiratory system. In swimming, prevention studies should focus on overuse injuries with emphasis on the upper extremity. Medical care at future FINA World Championships should institute measures to decrease the incidence of respiratory illnesses.
REFERENCES


CHAPTER 3

Competing with Injuries:
Injuries prior to and during the
15th FINA World Championships 2013
(Aquatics)


Chapter 3. Competing with Injuries:
Injuries prior to and during the 15th FINA World Championships 2013 (Aquatics)

ABSTRACT

Background
Injury and illness surveillance is the foundation for the development of prevention strategies.

Objective
To examine injuries amongst the aquatic disciplines in the four weeks prior to and during the 2013 FINA World Championships.

Methods
The study was comprised of two components: (a) a retrospective athlete survey recording injuries in the four weeks prior to the Championships, and (b) a prospective recording of injuries and illnesses by the medical teams of the participating countries and the local host medical team.

Results
One third of the 1,116 responding athletes reported an injury/physical complaint in the four weeks prior to the Championships. Significantly more women (36.7%) than men (28.6%) reported injuries. Divers reported the highest rate of injury/physical complaints (55.7%). At the start of the Championships, 70% of injured respondents (n=258) were still symptomatic, however full participation was reported by 76%. During the Championships, 186 new injuries were reported (8.3 per 100 registered athletes) with the highest injury incidence rate in water polo (15.3 per 100 registered athletes). The most common injured body part was the shoulder (21%). A total of 199 illnesses were reported during the Championships (9.0 per 100 registered athletes) with the most common diagnosis of illness being gastrointestinal infection. Environmental exposure (allergy, otitis, and jellyfish stings) was responsible for 27% of all illnesses in open water swimming.

Conclusion
Injuries pose a significant health risk for elite aquatic athletes. A prospective study would improve understanding of out-of-competition injuries. Future injury and illness surveillance at FINA World Championships is required to direct and measure impact of prevention strategies.
INTRODUCTION

From the recreational to the elite level, aquatic sports are universally popular around the world. In 2013, FINA, the international federation governing aquatic sports, held its 15th World Championships in Barcelona, Spain involving 2,223 athletes from 177 countries competing in 68 events in the disciplines of swimming, water polo, diving, synchronised swimming and open water swimming. The 30m platform diving event was introduced at these Championships.

FINA implemented its first injury surveillance at its World Championships in Rome 2009.1 Water polo also participated in the injury surveillance study of team sports during the 2004 Olympic Games, 2 and all aquatic disciplines were surveyed in the 20083 and 20124 Olympic Games. Illness surveillance was implemented in the FINA World Championships 20091 and in the 2012 Olympic Games.4

Results from the 2009 survey revealed that overuse (37.5%) was the most common mechanism for injury.1 Similarly, at the 2012 Olympic Games, diving had the highest incidence of overuse injuries (73%) compared to all sports.4 The injury registration methodology utilized in the FINA and IOC injury surveillance studies however, only records newly acquired injuries without capturing injuries incurred during training. Especially in the time period before major competitions, athletes may continue to train and compete despite injury and other physical complaints.

To facilitate the development of future prevention strategies for aquatic athletes, this study (a) assessed the presence and characteristics of injuries and physical complaints in the four weeks before and at the start of the FINA World Championships 2013; and (b) described the incidence and nature of new-onset injuries and illnesses incurred during competition.
Chapter 3. Competing with Injuries:
Injuries prior to and during the 15th FINA World Championships 2013 (Aquatics)

METHODS

The study was implemented at the 2013 FINA World Championships in Barcelona, Spain. The Championships consisted of competitions in six disciplines, and the study population included all registered athletes. Informed consent was obtained via the athlete entry form. Ethical approval was obtained from the University of Oslo, School of Medicine Ethical Committee and the Col·legi Oficial de Metges de Barcelona.

The study involved two components: (a) a retrospective questionnaire on injuries and physical complaints in the four weeks prior to and at the start of the Championships to be completed by the athletes, and (b) a prospective survey of new-onset injuries and illnesses reported by the local organizing committee (LOC) and national medical teams.

Retrospective questionnaire on prior complaints

A retrospective survey on athletes’ injuries and physical complaints during the four weeks prior to the Championships was developed to capture the presence, number, location, and duration of injuries and physical complaints, as well as their effect on training and competition performance (Appendix 1). It included a modified, extended version of the four questions of the Oslo Sports Trauma Research Centre questionnaire.5

Athletes were asked to report all injuries or other physical complaints they experienced in the four weeks prior to the Championships, regardless of the consequences for participation in normal training and/or competition. These outcomes are subsequently referred to as ‘prior complaints’. The questionnaire was available in English, French and Spanish. Athletes received the questionnaires from their team physician, and returned them prior to or during the event either in person to a member of the research team or via a locked drop box located in a secure location at each training and competition venue, and the FINA office.
Prospective survey on new-onset injuries and illnesses

The prospective injury and illness surveillance was based on the IOC protocol, previously implemented at the 2009 FINA World Championships. The injury and illness report form was available in English, French, Spanish, Italian, and Russian. Daily reporting by the team physician and LOC medical staff was accomplished electronically or via a secured drop box.

Implementation

The purpose and logistics of the study were communicated electronically to the National Federations and team physicians registered in the FINA database three months prior to the Championships. The FINA Bureau Sports Medicine Liaison (MM) undertook a pre-event site visit to train the LOC medical staff. Prior to the opening ceremony and prior to the commencement of the second week, an educational session was held for all national federation and LOC physicians. The study logistics were also presented at the technical meetings of each discipline.

During the competitions, members of the FINA Study Group attended every competition event to encourage reporting compliance. Injury and illness data gathered by the LOC from the training/competition sites, medical clinics, athlete hotels and the Championship hospital network were obtained daily from the Chief Medical Officer’s utilization report database. There was a daily review of the quality of the data and an analysis of reporting compliance. The medical staff of non-compliant countries was subsequently contacted to encourage reporting. Duplication of data entries of injuries and illnesses was resolved by the consensus of MM and AJ.

Definitions and calculation of exposure data and incidences

A discipline was defined as one of the six aquatic sports (swimming, diving, high diving, open water swimming, synchronized swimming and water polo). An event was defined as a competition activity for medals were awarded (e.g. 1m, 3m and 10m diving). Competing athletes in the individual events were calculated from the official start lists. Athletes starting in different events, were included for each event. Athletes who did not finish or were disqualified were
Chapter 3. Competing with Injuries:
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included as competing athletes.

The number of **starts** was calculated using the official results list. For the individual sports, the number of results including disqualifications and athletes who did not finish were each included as a start; e.g. an athlete competing in the heats, semi-finals and finals of a swimming event was counted as three starts. Athletes who started in different disciplines (e.g. swimming and open water swimming) were counted for each discipline. For swimming relays, synchronized swimming events, synchronised diving and open water swimming team events, the number of starts was calculated by multiplying the number of athletes on a team by the number of entries. For water polo, the number of starts was calculated as number of player-matches (2 teams x 7 players x the number of matches played).

The number of **athlete competition days** was calculated by multiplying the number of registered athletes in each discipline by the total number of days of competition for the respective discipline as per the official competition schedule.

**Calculation of incidences and data analysis**

**Incidence rates** were calculated as the number of injuries or illnesses per 100 registered or competing athletes in the respective discipline.

Data were processed using Excel and SPSS. Statistical methods applied were descriptive statistics, cross tabulations, Chi²- and t-test. For incidence rates, 95% confidence intervals (CIs) were calculated. Statistical significance was accepted at a p value of 0.05 or lower.

**RESULTS**

**Number and exposure of athletes**

A total of 2,223 athletes from 177 countries registered for the 2013 FINA World Championships
that resulted in almost 20,000 athlete competition days. As most athletes, except high divers and water polo players, competed in more than one event, the number of competing athletes was almost double the number of registered athletes. Overall, more female (53%) than male athletes (47%) participated. The athletes’ ages range from 12 to 41 years with an average of 22.2 years (SD 4.42). For further details on the characteristics of the athletes and their exposure see Table 1.

Table 1. Population characteristics and exposure during the FINA World Championships 2013

<table>
<thead>
<tr>
<th></th>
<th>Swimming</th>
<th>High diving</th>
<th>Diving</th>
<th>Synchro swimming</th>
<th>Open water</th>
<th>Water polo</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td># Registered athletes</td>
<td>1,671(668/683)</td>
<td>21(15/6)</td>
<td>228(116/112)</td>
<td>355(95/60)</td>
<td>127(90/75)</td>
<td>426(211/135)</td>
<td>2,223(1,046/1,177)</td>
</tr>
<tr>
<td>(male/female)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean age of athletes</td>
<td>21.5(2.84)</td>
<td>20.0(6.48)</td>
<td>21.7(6.03)</td>
<td>20.1(3.59)</td>
<td>22.6(4.58)</td>
<td>25.0(4.79)</td>
<td>22.2(4.42)</td>
</tr>
<tr>
<td>(SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># Events</td>
<td>40</td>
<td>2</td>
<td>16</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>68</td>
</tr>
<tr>
<td># Competing athletes</td>
<td>2,222(1,213/1,010)</td>
<td>20(14/6)</td>
<td>369(185/184)</td>
<td>643(96/43)</td>
<td>354(186/156)</td>
<td>416(208/208)</td>
<td>4,004(2,317/2,687)</td>
</tr>
<tr>
<td>(male/female)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># Starts (male/female)</td>
<td>3,102(1,652/1,450)</td>
<td>20(14/6)</td>
<td>499(309/304)</td>
<td>1,039(811/039)</td>
<td>354(198/156)</td>
<td>1,232(616/616)</td>
<td>6,356(2,785/3,571)</td>
</tr>
<tr>
<td>Duration in days</td>
<td>8(8.8)</td>
<td>3(2/1)</td>
<td>9(9.9)</td>
<td>8(8.8)</td>
<td>5(4/4)</td>
<td>14(7/7)</td>
<td>17(17/17)</td>
</tr>
<tr>
<td>(male/female)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># Athletes’ competition days</td>
<td>8,568</td>
<td>62</td>
<td>2,652</td>
<td>2,448</td>
<td>855</td>
<td>5,964</td>
<td>19,050</td>
</tr>
</tbody>
</table>

Retrospective questionnaire on prior complaints

A total of 1,116 athletes (610 women and 500 men) completed the retrospective survey of prior complaints representing an overall response rate of 50.2%; varying by discipline from 38.6% (diving) to 81% (high diving). Survey responders and non-responders were similar in age and gender, however were statistically different with regard to distribution by discipline (Table 2).

Approximately one third of the responding athletes (n=368; 33.0%) reported a physical complaint in the four weeks prior to the Championships. The duration of prior complaints varied from seven days to ten years with a median duration of 85.3 days. The mean age of athletes with and without prior complaints was similar. Significantly more females (n=224; 36.7%) than males (n=143; 28.6%) reported prior complaints (Chi²=7.83; p<0.005), and the proportion of athletes with a
prior complaint differed with statistical significance between disciplines (chi²=68.2; p<.001). More than half of the divers (55.7%) reported prior complaints, whereas only 17.4% of open water swimmers reported prior complaints.

More than three quarters of athletes with prior complaints (n=273; 76%) reported full participation in training in the four weeks leading up to the Championships but only 57 (17.0%) reported their performance had not been affected due to injury. The median number of days of limited sport participation was 6. High diving and water polo had the greatest number of days of limited performance.
The role of International Sports Federations in safeguarding the health and well-being of athletes

Lessons learned from FINA’s activities

Table 2 Number and characteristics of responders, injuries and complaints of in the four weeks prior to and at the start of the FINA World Championships 2013.

<table>
<thead>
<tr>
<th></th>
<th>Swimming</th>
<th>High diving</th>
<th>Diving</th>
<th>Synchronized swimming</th>
<th>Open water</th>
<th>Water polo</th>
<th>Total *</th>
</tr>
</thead>
<tbody>
<tr>
<td># Responding athletes (♂/♀/female)</td>
<td>464 (260/214)</td>
<td>17 (4/3)</td>
<td>88 (38/50)</td>
<td>122 (63/59)</td>
<td>87 (45/42)</td>
<td>329 (153/176)</td>
<td>1,116 (500/616)</td>
</tr>
<tr>
<td>% responders (♂/♀/female)</td>
<td>43.3 (41.1/46.2)</td>
<td>81.0 (93.3/50.0)</td>
<td>38.6 (32.8/44.6)</td>
<td>39.9 (39/8.9)</td>
<td>50.9 (46.9/56.0)</td>
<td>77.2 (72.5/81.9)</td>
<td>90.2 (47.8/51.8)</td>
</tr>
<tr>
<td>% responders with prior complaint (♂/♀/female)</td>
<td>23.5 (21.6/25.7)</td>
<td>22.5 (28.6/40)</td>
<td>55.7 (57/54.0)</td>
<td>42.6 (50.4/26.6)</td>
<td>17.4 (15.6/10.0)</td>
<td>41.9 (35.6/46.0)</td>
<td>33.0 (28.6/36.7)</td>
</tr>
<tr>
<td>Mean age of responders (SD)</td>
<td>21.9 (3.84)</td>
<td>29.3 (4.82)</td>
<td>21.4 (3.87)</td>
<td>19.7 (3.27)</td>
<td>22.1 (4.77)</td>
<td>24.5 (4.33)</td>
<td>22.5 (4.35)</td>
</tr>
<tr>
<td>Mean age of injured athletes (SD)</td>
<td>22.1 (4.08)</td>
<td>29.3 (5.74)</td>
<td>20.9 (3.69)</td>
<td>18.9 (3.00)</td>
<td>23.8 (4.51)</td>
<td>24.2 (3.85)</td>
<td>22.4 (4.31)</td>
</tr>
<tr>
<td>Participation in previous 4 weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full (%)</td>
<td>84.0</td>
<td>75.0</td>
<td>62.3</td>
<td>78.4</td>
<td>80.0</td>
<td>72.9</td>
<td>76.0</td>
</tr>
<tr>
<td>Reduced (%)</td>
<td>14.2</td>
<td>0</td>
<td>34.7</td>
<td>19.6</td>
<td>20.0</td>
<td>26.3</td>
<td>22.3</td>
</tr>
<tr>
<td>Unable (%)</td>
<td>1.8</td>
<td>25.0</td>
<td>3.0</td>
<td>2.0</td>
<td>0</td>
<td>0.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Average no. of body parts (SD)</td>
<td>1.28 (0.80)</td>
<td>1.25 (0.90)</td>
<td>1.17 (0.52)</td>
<td>1.65 (0.93)</td>
<td>1.53 (0.92)</td>
<td>1.43 (0.85)</td>
<td>1.38 (0.82)</td>
</tr>
<tr>
<td>Days of limited performance in previous 4 weeks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 (%)</td>
<td>15.6</td>
<td>25.0</td>
<td>20.4</td>
<td>18.4</td>
<td>50.0</td>
<td>13.3</td>
<td>17.0</td>
</tr>
<tr>
<td>1-3 (%)</td>
<td>18.8</td>
<td>-</td>
<td>13.0</td>
<td>20.4</td>
<td>-</td>
<td>17.2</td>
<td>16.7</td>
</tr>
<tr>
<td>4-7 (%)</td>
<td>38.5</td>
<td>50.0</td>
<td>26.1</td>
<td>22.4</td>
<td>8.3</td>
<td>26.6</td>
<td>29.2</td>
</tr>
<tr>
<td>8-14 (%)</td>
<td>14.6</td>
<td>-</td>
<td>15.0</td>
<td>24.5</td>
<td>8.3</td>
<td>14.8</td>
<td>15.8</td>
</tr>
<tr>
<td>15-27 (%)</td>
<td>7.3</td>
<td>-</td>
<td>15.0</td>
<td>6.1</td>
<td>25.0</td>
<td>13.3</td>
<td>11.0</td>
</tr>
<tr>
<td>28-30 (%)</td>
<td>5.2</td>
<td>25.0</td>
<td>10.5</td>
<td>8.2</td>
<td>8.3</td>
<td>14.8</td>
<td>10.4</td>
</tr>
<tr>
<td>Median days (IQR) *</td>
<td>5.0 (8.0)</td>
<td>6.0 (8.5)</td>
<td>5.5 (11)</td>
<td>6.0 (11)</td>
<td>2.0 (20)</td>
<td>7.0 (12)</td>
<td>6.0 (11.5)</td>
</tr>
</tbody>
</table>

Symptoms at start of competition

|                      | None (%) |                |            |            |            |
|----------------------|----------|----------------|------------|------------|
| Minor (%)            | 48.7     | 50.0           | 54.2       | 42.4       | 21.5       | 48.6       | 47.5     |
| Moderate (%)         | 13.8     | -              | 20.8       | 26.9       | 14.4       | 16.9       | 18.3     |
| Major (%)            | 0.8      | 25.0           | 2.1        | 1.9        | 7.1        | 2.9        | 2.5      |
| No participation (%) | -        | 25.0           | 2.1        | 1.9        | -          | -          | 0.8      |

Performance affected at start of competition

|                      | Not at all (%) |            |            |            |
|----------------------|----------------|------------|------------|
| Minor (%)            | 55.5           | 25.0       | 43.8       | 50.0       | 64.3       | 55.9       | 53.4     |
| Moderate (%)         | 37.6           | -          | 33.4       | 40.4       | 7.1        | 31.6       | 33.4     |
| Major (%)            | 6.9            | 25.0       | 12.5       | 5.8        | 21.5       | 8.1        | 8.7      |
| No participation (%) | -               | 25.0       | 8.3        | -          | 7.1        | 4.4        | 3.4      |

* sum might be less than the total due to missing values

**IQR= interquartile range
Chapter 3. Competing with Injuries:

Injuries prior to and during the 15th FINA World Championships 2013 (Aquatics)

At the start of the Championships, less than one third of athletes with prior complaints (30.9%) reported no current symptoms, 47.5% reported minor, 18.3% moderate and 2.5% severe symptoms. More than half (53.4%) reported no effect on performance from their prior complaints at the beginning of the Championships. In contrast, four athletes were unable to participate in the Championships and 1.4%, despite being severely affected, still competed.

Prospective survey on new-onset injuries and illnesses during the Championships

The medical staff from 55 (31.1%) countries submitted 587 injury and illness report forms covering a total of 1,571 athletes (70.7%) (Table 3). A total of 186 injuries was reported representing an incidence of 8.3 per 100 registered athletes (CI95% +/-1.19). The highest injury incidence was observed in water polo, followed by open water swimming and diving, and the lowest incidence in synchronized swimming. The incidence of injuries was higher in training (3.61; CI95% +/-0.78) than in competition (2.4; CI95% +/-0.48). No other differences were found. Thirty-two injuries (17%) were reported as resulting in time-loss, equivalent to an incidence of 1.4 per 100 athletes (CI 95% +/-0.49). Information on time loss was missing for 58 (31.2%) injuries. The rate of time-loss injuries was lower in male (1.34; CI 95% +/-0.7) than in female athletes (1.53; CI95% +/-0).
**Table 3.** Number and incidence (95% CI) of injuries and illnesses during the FINA World Championships 2013.

<table>
<thead>
<tr>
<th>Category</th>
<th>Swimming</th>
<th>High diving</th>
<th>Diving</th>
<th>Synchro. swimming</th>
<th>Open water</th>
<th>Water polo</th>
<th>Total (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>All injuries (male/female)</td>
<td>65 (31/34)</td>
<td>1 (1/-)</td>
<td>26 (10/16)</td>
<td>5 (5/3)</td>
<td>20 (11/9)</td>
<td>65 (33/32)</td>
<td>186 (88/98)</td>
</tr>
<tr>
<td>per 100 registered athletes</td>
<td>6.1</td>
<td>4.8</td>
<td>11.4</td>
<td>1.6</td>
<td>11.7</td>
<td>15.3</td>
<td>8.3 (1.19)</td>
</tr>
<tr>
<td>per 100 athletes’ competition days</td>
<td>0.7</td>
<td>1.5</td>
<td>1.3</td>
<td>0.2</td>
<td>2.3</td>
<td>1.1</td>
<td>0.5</td>
</tr>
<tr>
<td>Training injuries</td>
<td>46</td>
<td>0</td>
<td>12</td>
<td>1</td>
<td>4</td>
<td>18</td>
<td>81</td>
</tr>
<tr>
<td>per 100 registered athletes</td>
<td>4.3</td>
<td>0</td>
<td>5.3</td>
<td>0.3</td>
<td>2.3</td>
<td>4.2</td>
<td>3.6 (0.78)</td>
</tr>
<tr>
<td>Competition injuries</td>
<td>16</td>
<td>1</td>
<td>14</td>
<td>4</td>
<td>16</td>
<td>47</td>
<td>98</td>
</tr>
<tr>
<td>per 100 competing athletes</td>
<td>0.7</td>
<td>5.0</td>
<td>3.8</td>
<td>0.6</td>
<td>4.5</td>
<td>11.3</td>
<td>2.4 (0.48)</td>
</tr>
<tr>
<td>per 100 starts</td>
<td>0.5</td>
<td>5.0</td>
<td>2.3</td>
<td>0.4</td>
<td>4.5</td>
<td>3.8</td>
<td>1.5 (0.3)</td>
</tr>
<tr>
<td>Time-loss injuries (male/female)</td>
<td>12 (2/10)</td>
<td>0</td>
<td>7 (2/5)</td>
<td>0</td>
<td>2 (1/1)</td>
<td>11 (9/2)</td>
<td>32 (14/18)</td>
</tr>
<tr>
<td>per 100 registered athletes</td>
<td>1.1</td>
<td>0</td>
<td>3.1</td>
<td>0</td>
<td>1.2</td>
<td>2.6</td>
<td>1.4 (0.49)</td>
</tr>
<tr>
<td>Time-loss training injuries</td>
<td>8</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>per 100 registered athletes</td>
<td>0.75</td>
<td>0</td>
<td>1.75</td>
<td>0</td>
<td>0.94</td>
<td>0.72</td>
<td>0.35</td>
</tr>
<tr>
<td>Time-loss competition injuries</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>16</td>
</tr>
<tr>
<td>per 100 competing athletes</td>
<td>0.18</td>
<td>0</td>
<td>0.81</td>
<td>0</td>
<td>0.56</td>
<td>1.68</td>
<td>0.40 (0.2)</td>
</tr>
<tr>
<td>per 100 starts</td>
<td>0.1</td>
<td>0</td>
<td>0.5</td>
<td>0</td>
<td>0.6</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>All illnesses (male/female)</td>
<td>95 (51/44)</td>
<td>0</td>
<td>9 (6/3)</td>
<td>23 (-/23)</td>
<td>37 (21/16)</td>
<td>35 (14/21)</td>
<td>199 (92/107)</td>
</tr>
<tr>
<td>per 100 registered athletes</td>
<td>8.9</td>
<td>0</td>
<td>3.9</td>
<td>7.5</td>
<td>21.6</td>
<td>8.2</td>
<td>9.0 (1.25)</td>
</tr>
<tr>
<td>per 100 athletes’ competition days</td>
<td>1.1</td>
<td>0</td>
<td>0.4</td>
<td>0.9</td>
<td>4.3</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Time-loss illnesses (male/female)</td>
<td>8 (4/4)</td>
<td>0</td>
<td>3(2/1)</td>
<td>2 (-/2)</td>
<td>2 (1/1)</td>
<td>10 (5/5)</td>
<td>25 (12/13)</td>
</tr>
<tr>
<td>per 100 registered athletes</td>
<td>0.75</td>
<td>0</td>
<td>1.3</td>
<td>0.7</td>
<td>1.1</td>
<td>2.3</td>
<td>1.1 (0.43)</td>
</tr>
<tr>
<td>per 100 athletes’ competition days</td>
<td>0.1</td>
<td>0</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>

* sum might be less than the total due to missing values

** if 1 athletes started in different disciplines they were counted for each discipline
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The most common injured body part was the shoulder (n=39; 21%) (Figure 1). Almost half (49%) of the shoulder injuries and two-thirds of the time-loss shoulder injuries were reported in swimming. Water polo was responsible for two-thirds (n=23) of all injuries to the head/neck. The most common injury type was contusion (n=38; 20.4%), and the most frequent injury type was tendinosis of the shoulder (n=17). The most common cause of injury was contact with another athlete (n=46; 24.7%). Eight percent of the reported injuries resulted in time loss of 1-2 weeks duration, and one quarter of all time-loss injuries were to the shoulder (n=28). Data on time-loss were missing in 53 (28%) cases.
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Figure 1 Injury location for new-onset injuries during the FINA World Championships 2013.
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A total of 199 illnesses was reported during the Championships resulting in an incidence of 9.0 per 100 registered athletes (CI95% +/-1.25). There was no significant statistical difference between the number of illnesses reported in male (8.8; CI95% +/-1.8) and female (9.1; CI95% +/-1.72) athletes. The highest rate of illness was reported in open water swimmers while no illnesses were reported in high divers (Table 3). The most common diagnosis of illness was gastrointestinal infection, with environmental exposure resulting in allergic reactions, otitis, and jelly fish stings in open water swimming accounting for 27% of all reported illnesses (Figure 2). Twenty-five illnesses were reported to result in time-loss; resulting in a rate of 1.1 (CI95% +/-0.43) time-loss injuries per 100 registered athletes. Data on time-loss were missing in 64 (32%) cases. The highest rate of time-loss illnesses was observed in water polo.
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Figure 2 Diagnosis of illnesses during the FINA World Championships 2013
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DISCUSSION

Accurate injury surveillance is a fundamental component of effective risk management in sport.\textsuperscript{8-11} Despite the fact that out-of-competition prospective cohort studies are recommended to monitor injury patterns and risk,\textsuperscript{12-15} no studies of this type have been undertaken in aquatic sport disciplines. One prospective study monitoring shoulder pain in Australian swimmers\textsuperscript{16} and one descriptive retrospective epidemiologic study\textsuperscript{17} in NCAA swimming have been published.

Retrospective questionnaire of prior complaints

The retrospective component of this study is the first to evaluate the presence of out-of-competition injuries in international, elite aquatic athletes. Despite employing a narrow recall period of 4 weeks and a research population comprising only elite athletes, limitations to the accuracy of the retrospective survey exist with a potential for underestimation of injuries related to a potential recall bias.\textsuperscript{18,19} The more severe injuries of athletes who are subsequently unable to qualify for the FINA World Championships were not captured in this study. As such, the injury rates reported in this study are likely an underestimation of actual injury rates in elite aquatic athletes. In contrast, a strength of this survey was the recording of athlete symptoms rather than diagnoses, which allowed for greater capture of performance affecting physical complaints by bypassing potential reporting bias of third party recorders who may interpret differently a recordable problem. This approach provided a more accurate interpretation of the effect that physical complaints may have on athletic performance.\textsuperscript{13,14}

The survey responses demonstrated that almost a third of all athletes reported complaints, with 70% of them reporting prior complaints symptomatic at the commencement of the Championships. Despite these findings, the majority still participated in training stating that their athletic performance was affected by their prior complaint at the start of the competition. This finding is consistent with the literature outlining that athletes across sport disciplines continue to train despite injury\textsuperscript{13} and demonstrates the need for interventions to address the prevention of non-time-loss injuries. Further research in aquatic sports is required to determine whether symptomatic athletes are more vulnerable as previous injury is a known risk factor for injury.\textsuperscript{9} To
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achieve this end, prospective out-of-competition surveillance together with the standard in-competition protocol is recommended.

Prospective survey on new-onset injuries

The incidence of all and of time-loss injuries during the 2013 FINA World Championships was significantly higher than in 2009.¹ This trend may be due to increasingly tougher competition or to a busier competition calendar with a consequent decreased recovery period and a subsequent increased injury risk. It may also be attributed to improved familiarity of the team physicians with the injury surveillance system since a higher response rate was achieved in 2013 compared to FINA World Championships 2009.¹ A similar trend was observed in the Olympic Games.³, ⁴, ²⁰ Ongoing injury surveillance is required to decrease this reporting bias.

Consistent with previous published research, ¹, ¹⁶, ²¹-²⁵ the shoulder in aquatic sports was the most commonly injured body part. Despite various theories of risk factors and injury mechanisms, ¹⁶, ²⁵, ²⁶ shoulder injury prevention programmes for aquatic sports have not been validated in the scientific literature. Findings of the present study illustrate the need for a validated shoulder injury prevention program in the aquatic disciplines.

In the current study, the head and neck regions were the second most commonly reported injury locations. This unexpected finding was influenced by water polo, which reported more than 60% of all head and neck injuries. Water polo data also reflected the highest injury risk of all the aquatic disciplines with a higher number of head and neck injuries reported than shoulder injuries. A pragmatic approach to injury prevention in water polo would include a review of the current rules, de-emphasising contact, highlighting fair play and supporting the capacity for referees to sanction. These measures have been implemented in team sports such as football and rugby.²⁷-³²

Prospective survey on illnesses
During the 2013 FINA World Championships statistically significant more illnesses than in 2009 (7.1 per 100 athletes; 95%CI: 1.03) were reported. ¹ This could have been influenced by environmental risk variability between Barcelona (2013) and Rome (2009), but also the result of the improved athlete health care provision and improved reporting quality. Consistent with other sports, infection was the leading cause of illness.¹⁻³⁻³⁶ However, less upper respiratory infections were reported in 2013 (n=36; 18%) than in 20091 (n=91; 50.3%) possibly attributed to the presence of hand sterilizing stations on site and the education of athletes on personal hygiene.³⁷

Of particular concern was the reported frequency of otitis in all athletes (15% of all illnesses) and jelly-fish stings in open water swimmers (38% of illnesses in open water swimmers). These results demonstrate the need for the implementation of targeted preventive measures. The environmental risk posed by jelly-fish, warrants closer evaluation of open water venues to develop risk reduction measures and the provision of appropriate medication for the treatment of potential anaphylactic emergencies.

CONCLUSION

This study demonstrates the need to investigate out-of-competition (training) injury patterns in aquatic sports through prospective injury surveillance in aquatic sports. In-competition injury and illness surveillance should continue to gain further insight into trends and to evaluate the efficacy of prevention interventions. While the disciplines of swimming, diving and synchronized swimming have low injury rates relative to other sports, water polo has a uniquely higher propensity for injury distinctively affecting the head, neck and shoulder. Implementation of prevention interventions should target the discipline of water polo, shoulder and head injuries, as well as aquatic-specific illnesses such as jelly fish stings and otitis.

REFERENCES
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CHAPTER 4

The prevalence and characteristics of asthma in the aquatic disciplines

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J Allergy Clin Immunol. 2015; http://dx.doi.org/10.1016/j.jaci.2015.01.041
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ABSTRACT

Background: Despite the health benefits of swimming as a form of exercise, evidence exists that both the swimming pool environment and endurance exercise are etiological factors in the development of asthma. The prevalence of asthma in swimming is high as compared to other Olympic sport disciplines. There are no publications comparing the prevalence of asthma amongst the five aquatic disciplines.

Objective: The purpose of this study is to examine and compare the prevalence of asthma in the aquatic disciplines and in contrast with other Olympic sports.

Methods: Therapeutic Use Exemptions (TUEs) containing objective evidence of athlete asthma/airway hyper-responsiveness (AHR) were collected for all the aquatic athletes of swimming, diving, synchronized swimming, water polo and open water swimming for major events during the time period from 2004–2009. The prevalence of asthma/AHR in the aquatic disciplines was analyzed for statistical significance (95% CI), and also compared with other Olympic sports.

Results: Swimming had the highest prevalence of asthma/AHR in comparison with the other aquatic disciplines. The endurance aquatic disciplines have a higher prevalence of asthma/AHR than the aquatic non-endurance discipline. Asthma/AHR is more common in Oceania, Europe and North America than in Asia, Africa and South America. In comparison with other Olympic sports, swimming and synchronized swimming and open water swimming were amongst the top five sports for asthma/AHR prevalence.

Conclusion: Asthma/AHR in the endurance aquatic disciplines is common at the elite level, and has a varied geographical distribution. Findings from this study demonstrate the need for the development of aquatic specific prevention, screening and treatment regimens.
INTRODUCTION

Swimming is a common form of exercise enjoyed around the world from the recreational to the elite level. Swimming is practiced by all age groups and has been prescribed as a recommended form of exercise for asthmatics for many years by respiratory and family physicians as swimming was thought to be less likely to trigger the symptoms of asthma\(^4\) and is considered to be a safe, healthy activity\(^5,6\). However, evidence exists which implicates the aquatic environment itself as a cause of asthma/AHR through exposure of the airways to irritants such as pool chloramines\(^7\).

Asthma is diagnosed upon clinical presentation of a constellation of recurrent symptoms including cough, dyspnea, wheezing, chest tightness and the production of phlegm. Airway hyper-responsiveness (AHR) is a feature of asthma in which airways respond too much and too easily to stimuli\(^8\). Exercise-induced bronchoconstriction (EIB) refers to the acute narrowing of the airway resulting from exercise. It often occurs in dry/cold sporting environments such as ice-skating rinks environments with poor air quality and chlorine-disinfected swimming pools. EIB may be of variable severity and can affect athlete performance in addition to athlete health\(^8\).

The presence of asthma in elite swimmers seems multifactorial. For the competitive swimmer, high ventilation rates and volumes during training are implicated in the development of asthma through airway remodeling caused by chronic inflammation and/or epithelial damage\(^9\). Furthermore, exposure to the indoor aquatic environment may pose an increased risk of AHR by the inhalation of chloramines, a by-product of chlorine\(^10-13\). Inhaled chloramines are believed to induce disruption of the epithelial lining of the lung, promoting allergen sensitization\(^14\). Allergen exposure in sensitized individuals results in the release of inflammatory mediators and sensitization of airway smooth muscle leading to the development of airway remodeling\(^15\). Airway remodeling can also be seen in swimmers without evidence of AHR and is thought to be the result of fibrogenesis induced by prolonged training in a chlorinated environment\(^16\).

The ventilatory demands of endurance sport require the athlete to breathe at a high flow for repeated prolonged periods of time over an extended athletic career. Such ventilatory rates and
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volumes result in cooling and dehydration of the airway mucosa resulting in airway smooth
muscle contraction\textsuperscript{17}. Furthermore, hyperpnea-induced mechanical stress to the airways \textsuperscript{18}, may also constitute an insult to the epithelium, and can lead to an airway remodeling and subsequent changes in the contractile properties of the bronchial smooth muscle \textsuperscript{19}. In addition, during daily life or if training outdoors with a high ventilatory rate, the aquatic athletes can be exposed to other inhaled particulate matter which can also negatively affect airway integrity \textsuperscript{20}.

Due to the variation in requirements for elite performance between the aquatic disciplines, training regimens have evolved to be discipline-specific, with significant differences in physiological demands. These different types of training exposures may theoretically translate into differences in respiratory response to the training stimuli. While there are many studies published on the diagnosis and treatment of asthma in swimmers \textsuperscript{9, 16, 21-29}, to our knowledge, there are no publications studying asthma in the aquatic disciplines of synchronized swimming, open water swimming and diving, while there is only one study on adolescent water polo players \textsuperscript{30}. Understanding the health risks of the practice of aquatic sports is necessary to guide team physicians in their screening programs to optimize the health and performance of the elite level athlete as well as the recreational level athlete. Knowledge about the prevalence of asthma in the aquatic disciplines will be helpful in determining health promotion priorities for FINA.

It is hypothesized that asthma/ AHR is common in elite swimming, and in other endurance aquatic disciplines. In addition, it is hypothesized that the aquatic sports will have a higher prevalence of asthma/AHR than other Olympic sports, and that geographic variations in prevalence will be evident at the elite level. A unique large database containing objective evidence of asthma/AHR, will be analyzed to confirm the hypotheses and to formulate recommendations for future research. Therefore, the purpose of this study was i) to assess the overall prevalence of asthma/ AHR in aquatics; ii) to assess differences in prevalence in asthma/AHR between the aquatic disciplines; iii) to compare the prevalence of aquatic asthma/ AHR by geographical continent; iv) to compare the overall prevalence of asthma/ AHR between aquatic and non-aquatic athletes at the Olympic Games; and v) to compare the prevalence of endurance versus non-endurance sport disciplines.
METHODS

Determination of Study Period

We studied historical data derived from Therapeutic Use Exemptions (TUEs) containing the objective diagnoses of AHR of all competing aquatic athletes at the 2005, 2007, 2009 FINA World Championships and the 2004, 2008 Olympic Games. Commencing in 2002 the International Olympic Committee (IOC) instituted legislation requiring all athletes competing at the Olympic Games using inhaled β2 agonists to provide objective proof of AHR. In 2004, all inhaled β2 agonists including salbutamol, salmeterol, formoterol and terbutaline were placed on the WADA Prohibited List requiring pre-event medical demonstration of asthma/AHR to approve a TUE. Objective tests to establish a diagnosis of asthma/AHR included the demonstration of reversible airway obstruction obtained with a bronchodilator response (significant increase in forced expiratory volume in one second - FEV1) and/or a positive response to bronchial provocation testing (BPT) (see Table 1). In 2010, WADA removed the requirement for a TUE for salbutamol and salmeterol as urinary threshold levels for therapeutic use were established. Consequently, for the major aquatic competition events during the time period of 2004 – 2009, TUEs for AHR are available for all participating athletes.
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Table 1. Objective criteria required for athlete use of inhaled β2 agonists

<table>
<thead>
<tr>
<th>Objective Test</th>
<th>Criteria to be met for permission to use β2 agonists</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spirometry</strong></td>
<td></td>
</tr>
<tr>
<td>Bronchodilator test</td>
<td>≥12% increase in FEV₁ over baseline following inhalation of an inhaled beta 2 agonist</td>
</tr>
<tr>
<td><strong>Bronchial Provocation Tests</strong></td>
<td></td>
</tr>
<tr>
<td>Eucapnic Voluntary Hyperpnea</td>
<td>≥10% fall of FEV₁</td>
</tr>
<tr>
<td>Methacholine Aerosol challenge</td>
<td>≥20% fall of FEV₁ - PC20 &lt; 4mg/mL, [steroid naïve] or if taking inhaled GCS &gt; 1 month, then PD20 should be less or equal to 1600 mcg or PC20 less or equal to 16.0 mg/mL</td>
</tr>
<tr>
<td>Hypertonic Saline Aerosol challenge</td>
<td>15% fall of FEV₁ after inhaling or ≤ 22.5 ml 4.5% saline</td>
</tr>
<tr>
<td>Exercise Challenge Tests (field or laboratory)</td>
<td>≥10% fall of FEV₁</td>
</tr>
<tr>
<td>Histamine Challenge</td>
<td>≥20% fall of FEV₁ at a histamine concentration of 8mg/mL or less during a graded test of 2 minutes</td>
</tr>
<tr>
<td>Dry Powder Mannitol Challenge</td>
<td>15% fall of FEV₁ after inhaling ≤ 635 mg of mannitol</td>
</tr>
</tbody>
</table>

**Definition of asthma**

We considered that an athlete had asthma/AHR if he/she had an objective demonstration of airway obstruction from spirometry or BPTs as outlined in Table 1.
Acquisition and processing of nominator and denominator data

TUEs were obtained for the Olympic Games in 2004 and 2008 via the Chairman of the IOC TUE Committee (KF). The TUEs for 2005, 2007 and 2009 FINA World Championships were obtained from the FINA Anti-Doping archives. There was no major international aquatic competitive event in 2006. The Olympic TUE data were processed to isolate the TUEs for each of the aquatic disciplines of swimming, synchronized swimming, diving, water polo and open water swimming. All TUEs from the Olympic database and the FINA database were checked against the event participation database\textsuperscript{35,36} to confirm that the athlete with the granted TUE actually competed in the respective competitive event. TUEs for athletes who did not compete during the target competitive event were removed from the database.

TUEs granted by FINA had a duration of 4 years. As such, athlete participation in major competitive events was confirmed for the 4 years following the granting date of the TUE. For example, if an athlete was granted a TUE for asthma/AHR in 2005 and competed in 2007 and 2008, the athlete was added to the database for the subsequent years to be counted in prevalence analysis. TUEs granted by the IOC were valid for 4 years, and were also considered valid for the subsequent Olympic Games. Therefore, athletes with TUEs granted by the IOC in 2004 were reviewed for participation in subsequent FINA World Championships (2005 and 2007) and for participation in the 2008 Olympic Games. Athletes with TUEs granted by the IOC in 2008 were reviewed for participation in the FINA World Championships in 2009. Those athletes competing in subsequent events with a valid TUE were added to the respective data base for prevalence calculations. Prevalence was defined as the proportion of athletes at the target event competing with a TUE for asthma/AHR.

The total number of competing aquatic athletes in the FINA events was determined from the respective discipline-specific Omega results website\textsuperscript{35}. The total number of competing aquatic athletes for each discipline in the Olympic Games was obtained from the Olympic website\textsuperscript{36}.

The prevalence of asthma by geographical region for each major event was assessed. All
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participating athletes’ countries of origin were obtained from the official results database for the aquatic disciplines for each target event \(^{35, 36}\). These data were then categorized to their respective continents of Africa, Asia, Europe, North or South America and Oceania. The TUE data for each aquatic discipline were also classified by continent using the same procedure.

The prevalence of the non-aquatic Olympic sport disciplines was determined by extracting TUE files from the Olympic data base and categorizing each file by sport. Total athlete participation at the Olympic Games in both 2004 and 2008 for each sport discipline was determined from the official results found on the Olympic website.\(^{36}\)

Calculation of endurance versus non-endurance asthma prevalence comparisons required the classification of each of the aquatic disciplines as either endurance or non-endurance. Open water swimming, swimming, synchronized swimming and water polo were determined to be endurance events based on the physiological demands of these sports. Diving was classified as non-endurance. The Olympic non-aquatic sport disciplines were also classified as being either endurance or non-endurance based on unpublished WADA classification of doping risk for endurance sports \(^{37}\) (Table 2). The TUE data for both the aquatic and non-aquatic sport disciplines were also classified as endurance versus and non-endurance using the same procedure.
Table 2. Classification of Olympic sports by endurance versus non-endurance

<table>
<thead>
<tr>
<th>Endurance Sports</th>
<th>Non-Endurance Sports</th>
</tr>
</thead>
<tbody>
<tr>
<td>swimming</td>
<td>diving</td>
</tr>
<tr>
<td>synchronized swimming</td>
<td>badminton</td>
</tr>
<tr>
<td>water polo</td>
<td>judo</td>
</tr>
<tr>
<td>open water swimming</td>
<td>fencing</td>
</tr>
<tr>
<td>triathlon</td>
<td>sailing</td>
</tr>
<tr>
<td>modern pentathlon</td>
<td>equestrian</td>
</tr>
<tr>
<td>cycling</td>
<td>volleyball</td>
</tr>
<tr>
<td>rowing</td>
<td>gymnastics</td>
</tr>
<tr>
<td>hockey</td>
<td>boxing</td>
</tr>
<tr>
<td>football</td>
<td>tennis</td>
</tr>
<tr>
<td>athletics</td>
<td>shooting</td>
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<tr>
<td>softball</td>
<td>baseball</td>
</tr>
<tr>
<td>handball</td>
<td>wrestling</td>
</tr>
<tr>
<td>canoeing</td>
<td>basketball</td>
</tr>
<tr>
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<td>table tennis</td>
</tr>
<tr>
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<td>archery</td>
</tr>
<tr>
<td></td>
<td>taekwondo</td>
</tr>
<tr>
<td></td>
<td>weightlifting</td>
</tr>
</tbody>
</table>
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Analyses

Data were processed in an Excel database. Discipline and event specific asthma/AHR prevalence rates and corresponding 95% confidence intervals (95%CI) were calculated and compared, as the number of athletes with a TUE divided by the total number of competing athletes.

RESULTS

A total of 1,811 (1,441 from FINA and 370 from the IOC) TUEs from the aquatic disciplines for the study period were processed. Following the removal of TUEs for athletes who did not compete at the target events in the study period, a total of 1,468 aquatic TUEs comprised the study sample. For the non-aquatic Olympic sports, 920 TUEs were included in the study. The source population of aquatic athletes participating in the major events between 2004 and 2009 totaled 9,343. The total number of athletes competing in the 2004 and 2008 Olympic Games equaled 18,515.

The comparative prevalence rates of asthma/AHR in the aquatic sports can be found in Figure 1. The prevalence of asthma/AHR in swimming in comparison with all of the other aquatic disciplines was significantly higher except for a peak in both synchronized swimming and open water swimming at the 2008 Olympic Games with prevalence of 22.12% (95%CI: 14 – 31) and 26% (95%CI: 13 – 39) respectively. There was no difference in asthma/AHR prevalence rates in relation to gender for any of the aquatic disciplines.
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Figure 1. The prevalence of asthma in the aquatic disciplines for the 2004 and 2008 Olympic Games and for the FINA World Championships in 2005, 2007, and 2009.

Comparison of the continental prevalence of asthma/AHR in the aquatic sports can be found in Figure 2. The prevalence of reported asthma/AHR in aquatic athletes from North America, Oceania and Europe was significantly higher than in Asia for all target events. The African asthma/AHR prevalence data was significantly lower than in Oceania and Europe for all target events. Both Africa and South America had statistically significant lower prevalence rates than North America for all events except for the 2004 Olympic Games. There were no statistical difference in the prevalence of asthma/AHR in aquatic athletes between Asia, Africa and South America except for the 2004 Olympic Games where South America was higher. Likewise, there was no difference in the prevalence of asthma/AHR between Europe, Oceania and North America except for the 2008 Olympic Games and the 2009 FINA World Championships where North America showed a significantly higher prevalence in comparison to Europe.
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Figure 2. Prevalence of asthma in the Olympic sports of the 2004 and 2008 Olympic Games

Figure 3 illustrates the prevalence of asthma/AHR for all Olympic sports during the 2004 and 2008 Olympic Games. Sport disciplines requiring aerobic endurance training have a higher prevalence of asthma/AHR than those sports whose physiological demands are non-endurance in nature. When comparing the prevalence of asthma/AHR in the endurance versus non-endurance aquatic disciplines, the endurance disciplines were consistently higher for all of the target events in comparison with the non-endurance discipline of diving. Likewise, the endurance Olympic sports had a significantly higher prevalence of asthma/AHR than the non-endurance Olympic sports. The prevalence of asthma/AHR in the aquatic endurance disciplines was statistically higher than in the non-endurance Olympic sports. (Figure 4)
Figure 3. A comparison of the prevalence of asthma in the aquatic disciplines by continent for the 2004 and 2008 Olympic Games and for the FINA World Championships in 2005, 2007, and 2009.
Figure 4. Comparison of the prevalence of asthma in endurance versus non-endurance aquatic and non-aqueous Olympic sports for the 2004 and 2008 Olympic Games and for the FINA World Championships in 2005, 2007, and 2009.
DISCUSSION

This study is the first to report the comparison of asthma/AHR prevalence between the aquatic disciplines in the elite athlete population and in contrast with other Olympic sports. The predominant finding of a high prevalence of TUEs for inhaled β2 agonists (IBA) in swimming compared to the other aquatic disciplines is consistent with published data demonstrating a higher prevalence of asthma in swimmers than in the general population \(^{21,23,38}\). There is only one published study \(^{30}\) on asthma prevalence in water polo which showed no statistical difference between water polo, football and basketball in adolescent athletes. Asthma in this study, however, was defined by a fall of FEV1 of greater than 10% after an exercise challenge involving running in a small sample size \((n=30)\) and as such, the prevalence is likely underestimated \(^{30}\). The high prevalence of asthma/AHR in swimming relative to the other aquatic disciplines points to an etiological factor other than environmental exposure such as training intensity, type and/or duration. This finding underscores the necessity for further research to determine the etiological mechanism of asthma/AHR in swimming. A longitudinal study would be useful to ascertain the distinction between athletes with asthma who self-select to swimming and those who develop asthma as a result of exposure to endurance training practices. Although asthma is more common in women than in men in the general population, the lack of gender difference in asthma prevalence in this elite athlete population is attributed to the fact that both genders are equally exposed to the cause of asthma—namely endurance training and environmental irritants.

Utilizing a retrospective design of TUE analysis does not provide information about the natural history of asthma/AHR in the elite aquatic disciplines. Given the high prevalence of asthma/AHR
demonstrated in this study, the potential health burden in this population is important to ascertain. Knowledge of the long term health repercussions for the aquatic athlete post retirement is scarce. A study by Bougault et al. demonstrated some reversibility in AHR following a two-week or more rest period. Helenius et al. studied 42 Finnish swimmers prospectively over five years showing some reversibility. Further study in this area is however required.

The utilization of TUE data to diagnose asthma/AHR has inherent limitations and potential bias. TUE data may underrepresent the actual prevalence for athletes who do not have access to respiratory diagnostic facilities or to sports physicians knowledgeable of the WADA TUE program. On the other hand, there are published data to suggest that TUE data may overestimate the diagnosis of asthma/AHR. Published data demonstrates that BPT according to the WADA TUE criteria identified AHR in asymptomatic swimmers. It is postulated that exercising in the warm, humid ambient environment of the swimming pool may mitigate the triggers of asthma symptoms. Given the design of this current study, which evaluates a very large database of TUEs over an extended period of time on a worldwide scale in elite aquatics, these biases are likely not significant.

While there are differences in the prevalence of asthma/AHR in different geographic locations in the general population globally due to environmental influences and varying medical awareness and practices, the findings of this study raise questions for the elite aquatic athlete that warrant further evaluation. Is the lower prevalence in Asia and Africa due to a lack of access to diagnostic equipment, or represents a geographical variation in medical practice? Is there a racial genetic protection for asthma/AHR which correlates with athletic performance? Another
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explanation is that there may be geographic variations in pool environment regulations for chlorination and thus resulting in the geographical prevalence differences. A final postulate is that the lower prevalence of asthma/AHR in Africa may be due to the fact that Africa has a lower participation rate in elite aquatics (except for South Africa); however this postulate is not applicable to Asia which enjoys high participation rate in elite aquatic swimming.

An interesting finding of this study is the increased prevalence of TUE applications during the 2008 Olympic Games in Beijing, China. This spike in prevalence was likely due to an increased awareness of the medical staff of the relatively high levels environmental air pollution in the region prompting concern for extraneous environmental triggers for asthma and/or an increasing familiarity of the TUE process. Why then, does Asia have a relatively low TUE prevalence in comparison to other geographic regions, when air quality is a concern in the region? Anti-doping rule violations for IBA during this time period were rare resulting in only two for terbutaline from France (2007, 2009) and two for formoterol in 2009 from China and Australia, demonstrating that athletes were not being treated for asthma/AHR without valid TUEs. Further study in these geographic regions is warranted to evaluate the cause of these findings.

Findings from this study demonstrating the high prevalence of asthma/AHR in endurance versus non endurance sports are consistent with previously published studies showing that endurance training itself is an etiological factor in the development of asthma. This finding raises the question as to whether prolonged endurance training leading to the development of asthma has a negative effect on performance. A study evaluating athlete performance with a TUE for IBA in
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the 2000 Sydney Olympic Games showed that the 5.7% of athletes with a valid TUE for IBA were responsible for winning 7.2% of the medals. Likewise, in a study of TUE in the 2004 Athens Olympic Games, McKenzie demonstrated that 4.2% of all athletes with a TUE for IBA won 5.4% of all individual medals. Fitch looked specifically at swimming results in the 2008 Beijing Olympic Games and reported that of the 19.3% of swimmers with a TUE for IBA won 32.9% of all aquatic medals. Clearly, asthma/AHR in the elite swimmer does not have a negative effect on performance; and indeed, this study demonstrates the opposite; that athletes with TUE for asthma/AHR perform better.

There are many possible theories for why athletes with asthma perform better than athletes without asthma. Is this phenomenon due to a longer training period resulting in the development of asthma along with more efficient swimming skills? Does this represent a genetic predisposition for asthma and superior aquatic performance? It also raises the question as to whether the use of IBA or ICS therapy are performance enhancing. Kuipers, Kinderman and Pluim have shown that neither substance, when used in therapeutic doses, is performance enhancing. Could there be a perceived placebo effect of performance enhancement by using IBA? Couto demonstrated that the prevalence of asthma/AHR declaration decreased by half when the mandatory objective measures required by WADA were implemented suggesting that prior to the WADA TUE requirements, athletes were using IBA without an accurate diagnosis of asthma/AHR; potentially for the falsely perceived performance benefit of the drugs. In a study of asthma/AHR prevalence in the British swimming team showed the opposite however, with a rise from 41% in the 2000 Sydney Games in contrast to 44% in the 2004 Athens Olympic Games. Findings from this current study also showed a rise in prevalence in asthma/AHR in the
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Aquatics disciplines from the 2004 to the 2008 Olympic Games. Could the perceived performance advantage be the reason for the peak in asthma/AHR prevalence in the 2008 Beijing Olympic Games seen in swimming, synchronized swimming and open water swimming? More likely, concern for the environmental safety of the air quality in Beijing prompted team physicians to pursue TUE application even in asymptomatic athletes.

The outcomes of this study demonstrate the need for FINA to develop educational initiatives for aquatic team physicians addressing prevention, screening and treatment of asthma in swimming. In addition, host medical services for aquatic competitions should plan to have rescue β2 agonists available at all competition and training venues.

CONCLUSIONS

The key finding from this study is that swimming has a higher prevalence of asthma/AHR relative to the other aquatic disciplines. In addition, the data also supports the hypothesis that elite endurance athletes have a higher prevalence of asthma/AHR than non-endurance athletes. Geographical variations in asthma/AHR prevalence in aquatics raise many questions requiring further investigation.

The high prevalence of asthma/AHR in swimmers in comparison to the other aquatic disciplines and Olympic sports underscores the need for FINA to develop strategies to prevent, identify and treat asthma/AHR in this athletic population. Further research is required to better delineate the pathophysiological mechanisms for the development of asthma/AHR in the aquatic athlete and
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the natural history of the disease post retirement to assess long term health consequences for athletes who develop asthma as a result of aquatic endurance training. Despite the increased risk of asthma in elite swimming, the physical, mental health and lifestyle benefits of the sport participation are numerous in comparison with the general population. With attention to the findings and recommendations resulting from this study, healthy participation in swimming at the elite level can be improved and enjoyed.

ABBREVIATIONS

AHR: Airway hyper responsiveness
β2 agonists: Beta-2 agonists
BPT: Bronchial provocation test
EIB: Exercised-induced bronchoconstriction
FEV1: Forced expired volume in one second
FINA: Federation Internationale Natation Amateur
IBA: Inhaled Beta2 agonist
ICS: Inhaled Corticosteroid
IOC: International Olympic Committee
SABA: Short acting Beta2 agonist
TUE: Therapeutic Use Exemption
WADA: World Anti-Doping Agency
REFERENCES


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37. Personal communication: Risk Assessment Working Group, WADA.


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CHAPTER 5

The IOC Consensus Statement:
Beyond the Female Athlete Triad --
Relative Energy Deficiency in Sport

ABSTRACT

Protecting the health of the athlete is a goal of the International Olympic Committee (IOC). The IOC convened an expert panel to update the 2005 IOC Consensus Statement on the Female Athlete Triad. This Consensus Statement replaces the previous and provides guidelines to guide risk assessment, treatment and return to play decisions. The IOC expert working group introduces a broader, more comprehensive term for the condition previously known as “Female Athlete Triad”. The term “Relative Energy Deficiency in Sport” (RED-S), points to the complexity involved and the fact that male athletes are also affected. The syndrome of Relative Energy Deficiency in Sports (RED-S) refers to impaired physiological function including, but not limited to, metabolic rate, menstrual function, bone health, immunity, protein synthesis, cardiovascular health caused by relative energy deficiency. The cause of this syndrome is energy deficiency relative to the balance between dietary energy intake and energy expenditure required for health and activities of daily living, growth and sporting activities. Psychological consequences can either precede RED-S or be the result of RED-S. The clinical phenomenon is not a ‘triad’ of the three entities of energy availability, menstrual function and bone health, but rather a syndrome that affects many aspects of physiological function, health and athletic performance. This Consensus Statement also recommends practical clinical models for the management of affected athletes. The “Sport Risk Assessment and Return to Play Model” categorizes the syndrome into three groups and translates these classifications into clinical recommendations.
INTRODUCTION

Protecting the health of the athlete is one of the goals of the International Olympic Committee (IOC). The Olympic Movement Medical Code, which governs the actions of the IOC Medical Commission and sport organizations, also emphasizes the importance of the protection of the health of the athlete. In 2005, the IOC published the Consensus Statement (Consensus Statement) and the IOC Position Stand (Position Stand) on the Female Athlete Triad. Based on scientific evidence published in the intervening period, this Consensus Statement serves to update and replace these documents and to provide guidelines to the athlete health support team to guide risk assessment, treatment and return to play decisions for affected athletes.

RELATIVE ENERGY DEFICIENCY IN SPORT

In the 2005 IOC Consensus Statement, the Female Athlete Triad (Triad) was defined as “the combination of disordered eating and irregular menstrual cycles eventually leading to a decrease in endogenous oestrogen and other hormones, resulting in low bone mineral density” based on the original scientific evidence of Drinkwater et al. In 2007, following progress in scientific understanding, the American College of Sports Medicine redefined the Triad as a clinical entity that refers to the “relationship between three inter-related components: energy availability (EA), menstrual function, and bone health”. Added was an understanding of the pathophysiology describing the concept that over a period of time, the athlete moves along on a continuous spectrum ranging from the healthy athlete with optimal EA, regular menses and healthy bones to the opposite end of the spectrum characterized by amenorrhea, low EA, and osteoporosis.

Since 2007, scientific evidence and clinical experience show that the etiological factor underpinning the Triad is an energy deficiency relative to the balance between dietary energy intake and the energy expenditure required to support homeostasis, health and the activities of daily living, growth and sporting activities. It is also evident that the clinical phenomenon is no longer only a triad of three entities of EA, menstrual function and bone health, but rather a syndrome resulting from relative
energy deficiency that affects many aspects of physiological function including metabolic rate, menstrual function, bone health, immunity, protein synthesis, cardiovascular and psychological health. In addition, it is evident that relative energy deficiency also affects males. Therefore, to more accurately describe the clinical syndrome originally known as the Female Athlete Triad, new terminology is required. Based on its interdisciplinary expertise, the IOC Consensus group introduces a more comprehensive, broader term for the overall syndrome, which includes what has so far been called the "Female Athlete Triad": **Relative Energy Deficiency in Sport (RED-S)**.

The syndrome of RED-S refers to impaired physiological function including, but not limited to, metabolic rate, menstrual function, bone health, immunity, protein synthesis, cardiovascular health caused by relative energy deficiency.

The underlying problem of RED-S is an inadequacy of energy to support the range of body functions involved in optimal health and performance. EA is calculated as energy intake minus the energy cost of exercise relative to fat-free mass (FFM) and in healthy adults, a value of 45 kcal/kg FFM/d equates energy balance.\(^7\) Low energy availability (LEA), which occurs with a reduction in energy intake and/or increased exercise load, causes adjustments to body systems to reduce energy expenditure, leading to disruption of an array of hormonal, metabolic and functional characteristics.\(^7\) Disordered eating underpins a large proportion of cases of LEA, but other situations, such as a mismanaged program to quickly reduce body mass/fat, or an inability to track energy intake with an extreme exercise commitment, may occur without such a psychological overlay.\(^7\)
Although the literature on LEA has focused on female athletes, it also has been reported to occur in male athletes. Prevalence studies of LEA in male athletes have been few, however LEA appears to occur among the same at risk sports as for female athletes: the weight sensitive sports in which leanness and/or weight are important due to their role in performance, appearance or requirement to meet a competition weight category.

Although simple messages about optimal, tolerable and unsafe levels of EA have been provided there are some caveats in the science. Firstly, the complex dose-response relationships between reduction in EA and the disruption of various hormones and bone formation markers vary in nature and thresholds. Therefore, the cost of any energy mismatch should be carefully considered before it is implemented. A second caveat is that it is now known that the resting metabolic rate in athletes of small body size is underestimated in the linear scaling of EA relative to LBM/FFM. Finally, findings from laboratory settings may not apply as cleanly to free-living athletes. Numerous studies in female athletes have failed to find clear thresholds or associations between field determinations of LEA and objective measures of energy conservation such as metabolic hormones and menstrual disturbances. It is possible that other factors seen in free-living populations such as psychological stress, greater variability in between- and within-day energy deficiency or dietary characteristics interact with each other to alter the effects of LEA.

**DISORDERED EATING AND EATING DISORDERS**

The disordered eating (DE) continuum starts with appropriate eating and exercise behaviors, including healthy dieting and the occasional use of more extreme weight loss methods such as short-term restrictive diets (<30 kcal/kg/1FFM/d-1). The continuum ends with clinical eating disorders (EDs), abnormal eating behaviors, distorted body image, weight fluctuations, medical complications and variable athletic performance. The DSM-5 diagnostic classifications for EDs include anorexia nervosa, bulimia nervosa, binge eating disorder and other specified and unspecified feeding or eating disorder. These EDs have many features in common, and athletes frequently move between them. The pathogenesis of EDs is multifactorial with cultural, familial, individual and genetic/biochemical factors.
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playing roles.\textsuperscript{17} In addition, factors specific to sport such as dieting to enhance performance, personality factors, pressure to lose weight, frequent weight cycling, early start of sport-specific training, overtraining, recurrent and non-healing injuries, inappropriate coaching behavior, and regulations in some sports have been suggested.\textsuperscript{8} The prevalence of EDs is about 20% and 13% among adult and adolescent female elite athletes, and 8% and 3% in adult and adolescent male elite athletes, respectively.\textsuperscript{15,18} The prevalence differs significantly between sports.\textsuperscript{15}

HORMONAL AND METABOLIC IMBALANCE

Eumenorrhea is defined as regular cycles occurring at intervals between 21 and 35 days. In adolescents, the cycles range between 21 and 45 days.\textsuperscript{19} Primary amenorrhea is defined as no menarche by age 15 years.\textsuperscript{20} Secondary amenorrhea refers to an absence of three consecutive cycles post menarche. Oligomenorrhea is defined as a cycle length greater than 45 days. Estimates of the prevalence of menstrual disorders in athletes vary widely.\textsuperscript{21} Secondary amenorrhea prevalence is estimated in collegiate women from 2 to 5% and as high as 69% in dancers\textsuperscript{22} and 65% in long-distance runners.\textsuperscript{23} Primary amenorrhea in collegiate athletes was found to be 7% overall, and was higher (22%) in cheerleading, diving and gymnastics.\textsuperscript{24} Subtle menstrual dysfunction, such as very light bleeding, mildly extended menstrual interval and pre- and post-menstrual spotting may occur, and may be underestimated by routine screening.\textsuperscript{25}

Abnormal levels of hormones,\textsuperscript{26} LH pulsatility, inadequate body fat stores, LEA and exercise stress may be etiological factors in menstrual disorders in athletes. Marked reduction in EA may disrupt the LH pulsatility by affecting the hypothalamic hormone Gonadotropin Releasing Hormone output\textsuperscript{27} which subsequently alters the menstrual cycle. This is known as Functional Hypothalamic Amenorrhea (FHA). Rapid or significant fat mass reduction, even over as short as a one-month period, may compromise menstrual function. LEA alters levels of metabolic hormones and substrates, e.g., insulin, cortisol, growth hormone, insulin-like growth factor-I (IGF-I), 3,3,5-triiodothyronine (T3), grehlin, leptin, peptide tyrosine-tyrosine (PYY), glucose, fatty acids, and ketones.\textsuperscript{28}
HEALTH AND PERFORMANCE CONSEQUENCES OF RELATIVE ENERGY DEFICIENCY IN SPORT

RED-S can have serious implications for many body systems, resulting in both short- and long-term compromise of optimal health and performance. Athletes who suffer from long-term LEA may develop nutrient deficiencies (including anaemia), chronic fatigue, and increased risk of infections and illnesses, all of which have the potential to harm both health and performance. Physiological and medical complications involve the cardiovascular, gastrointestinal, endocrine, reproductive, skeletal, renal, and central nervous systems. Psychological stress and/or depression can result in LEA and EDs and can also be a result of LEA. Research indicates that muscle protein synthesis is reduced even at energy availability of 30 kcal/kg FFM/d. LEA causes unfavourable lipid profiles and endothelial dysfunction thus increasing cardiovascular risk. Hormonal and metabolic abnormalities caused by RED-S and carbohydrate deficiency can result in a reduction in glucose utilization, mobilization of fat stores, slowing of metabolic rate, and growth hormone.

Irregular or absent menses may have significant emotional impact creating anxiety and an altered perception of self-normalcy. It may also confound conception, leading to unexpected pregnancy as well as inaccurate dating of pregnancy. Long-term reproductive repercussions of RED-S for females and males are unknown.

RED-S also has adverse health consequences for bone. Peak bone mass occurs around 19 years in women and 20.5 years in men. Estrogen increases uptake of calcium into blood and deposition into bone, while progesterone facilitates the actions of estrogen through multiple complex mechanisms. Even silent estrogen/progesterone imbalance, as seen in subclinical ovulatory disturbances with LEA may produce negative changes in bone. In men and women, testosterone has anabolic effects on bone, stimulating osteoclasts and increasing bone formation and calcium absorption. Low testosterone levels have been associated with low BMD in male athletes. Endogenous estrogens and androgens have independent effects on bone development in both sexes. Increases in the stress hormones, catecholamines and cortisol, concomitant with LEA, have a negative effect. The bones of athletes with chronic amenorrhea, benefit less from the osteogenic effects of exercise. Although low BMD was first attributed to hypoestrogenism of menstrual dysfunction, LEA is now recognised as an
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independent factor of poor bone health at all levels of energy deficiency due to decreased IgF-1 and bone formation markers levels. Bone loss in these athletes may be irreversible.

Changes to bone structure have been shown to lead to an increased risk of stress fractures, which cause severe impediments to training and competition performance. Dietary insufficiencies increase the risk of stress fractures in both sexes. Additional risk factors include menstrual dysfunction, compulsive exercise, underlying poor bone health, low BMI, prior fracture and eating psychopathology. High risk stress fractures (i.e. femoral neck) have been reported in adolescent athletes with the Triad, and can have serious long-term consequences.

Figure 1: Health Consequences of Relative Energy Deficiency in Sport (RED-S) showing an expanded concept of the Female Athlete Triad to acknowledge a wider range of outcomes and the application to male athletes (*Psychological consequences can either precede RED-S or be the result of RED-S) Adapted from Constantini 2002
RED-S can also affect athletic performance. Functional impairments associated with LEA include a greater prevalence of viral illnesses, injuries and most critically, reduced responsiveness to training and subsequent performance. Further studies of performance effects of LEA are likely to provide significant incentive to change damaging behaviours. Such studies should confirm under which situations these effects occur.

**Figure 2:** Potential Performance Effects of Relative Energy Deficiency in Sport (**Aerobic and anaerobic performance**) Adapted from Constantini 2002

In addition, athletes with DE/ED often practice extreme weight control methods (fasting, vomiting, diuretic and laxative abuse) that have possible health and performance consequences such as dehydration and electrolyte imbalances, and gastrointestinal problems, including esophagitis and esophageal perforation from vomiting. Diuretics and some diet pills may contain WADA prohibited substances.
MALE ATHLETES

Although there is a scarcity of prevalence studies in LEA in male athletes, Vogt et al.\textsuperscript{59} showed that male cyclists had severely reduced EA of 8 kcal/kg/FFM/d and Müller et al. have reported high prevalence of underweight international level ski jumpers.\textsuperscript{60} Although male athletes are at lower risk for developing DE/ED\textsuperscript{8,18,61} the prevalence in elite male athletes is high in cycling (50%),\textsuperscript{62} gravitational (24%) and weight class sports (18%).\textsuperscript{15} DE/EDs in male jockeys are associated with low BMD\textsuperscript{63} Even in the absence of DE/EDs, male endurance athletes in running\textsuperscript{37,64,65} and in non-weight bearing sports such as cycling,\textsuperscript{66-69} are at high risk for low BMD. LEA is known to alter endocrine function\textsuperscript{11} and direct and indirect impacts on bone may occur in male athletes.\textsuperscript{70}

ATHLETES OF NON-CAUCASIAN ETHNICITY

The prevalence of LEA has been studied mainly in females of Caucasian, European, or European American descent. Whether race plays a role in the incidence and underlying etiology of the RED-S remains speculative.

Race is a significant variable for several of the individual Triad components in non-athletic women. For example a lower risk of ED is shown in African American than Caucasian women,\textsuperscript{71} even among adolescent athletes.\textsuperscript{72} Whether the prevalence of menstrual disorders differs among racially diverse, athletic groups is currently unknown. In non-athletes, menarche occurs significantly earlier in African American than in Caucasian or European American women.\textsuperscript{73} The BMD of African American non-athletic females is significantly greater than that of Caucasian women, with a lower risk of osteoporosis and fracture.\textsuperscript{74} In athletes, little is known about the differences in BMD among ethnic groups, especially in the presence of LEA, DE/ED and hormonal and metabolic imbalances. Stress fractures in African American military recruits are lower than in Caucasian recruits.\textsuperscript{75} Based on preliminary data of a multi-center study, African American and African black athletes exhibit similar symptoms of LEA, with Caucasian athletes showing greater risk of DE/EDs and menstrual dysfunction\textsuperscript{76} and no advantage for BMD in African black athletes.\textsuperscript{77} There are no published scientific studies in Hispanic and limited evidence on Asian athletes.\textsuperscript{78}

ATHLETES WITH A DISABILITY
At present there are no data available on LEA in athletes with disabilities. Individuals with spinal cord injuries, suffer from osteoporosis due to the lack of skeletal loading.79 While no data exist on EA or DE/ED patterns in athletes with a disability, their occurrence should not be overlooked. RED-S in athletes with a disability should be taken seriously due to possible co-morbidities. Athletes with an amputation who are ambulating may have additional energetic challenges due to the inefficiency of movement,80 thus increasing their risk for inadvertent energy deficiency.81

SCREENING AND DIAGNOSIS

Relative Energy Deficiency and Eating Disorders in Sport

The screening and diagnosis of RED-S is challenging, as symptomatology can be subtle. A high index of suspicion of the athlete at risk is needed. Early detection is crucial to improve performance and prevent long-term health consequences. Screening for RED-S should be undertaken as part of an annual Periodic Health Examination (PHE) and when an athlete presents with DE/ED, weight loss, lack of normal growth and development, menstrual dysfunction, recurrent injuries and illnesses, decreased performance or mood changes. Although various screening instruments exist,16,82,83 they have not been validated and there is no consensus on which screening tool has the best efficacy.84,85 Furthermore, these tools exclude males, disabled athletes, and are not ethnically diverse.

Since LEA plays such a pivotal role in the development of the RED-S, diagnosis should focus on identification of the presence and causes of the LEA. Unfortunately, there are no standardised guidelines for the determination of EA. EA is equivalent to energy intake (EI) minus the cost of exercise energy expenditure (EEE) relative to fat-free mass or lean body mass: EA (kcal/kgFFM/d) = [EI (kcal/d) − EEE (kcal/d)]. The measurement of each of these components requires expertise and is generally imprecise. EI can be assessed by retrospective (recall) or prospective (written or electronic food diary) methods.86 EEE is usually assessed by an exercise log and tables of energy expenditure associated with sports/exercise activities, but may be supplemented where available by data collected via modern sports technology (e.g. Global Positioning System Units, Heart Rate Monitors or Power Meters). Ideally,
both EI and EEE are measured over a similar time period that is representative of habitual practices. Fat free mass can be quantified by methods such as dual-energy X-ray absorptiometry (DXA) and anthropometry. A measurement of Resting Metabolic Rate via indirect calorimetry may provide confirmation of suppressed metabolism secondary to LEA. Underpinning factors related to an unintentional mismatch between energy intake and large training/competition volume, intensity or misguided weight loss practices may be relatively easy to diagnose. The Brief Eating Disorder in Athletes Questionnaire (BEDA-Q) is a validated screening tool that shows promising results in terms of distinguishing between female elite athletes with and without an ED. The Gold Standard for the diagnosis of EDs is the Eating Disorder Examination interview (EDE-16). For diagnostic criteria for ED see APA.

Menstrual Dysfunction
FHA is a diagnosis of exclusion. Assessment of irregular menses should include a menstrual history assessing age of menarche, regularity of menses, use of medications, the presence of other health issues and a family menstrual history. Physical examination includes assessment of anthropometry, pubertal stage, signs of ED and secondary causes of amenorrhea. Pelvic examination may reveal pregnancy or hypoestrogen related vaginal atrophy. Laboratory assessment of hemoglobin, luteinising hormone, follicle stimulating hormone, prolactin, estradiol, T4, thyroid stimulating hormone, pregnancy, and androgen profile may be indicated. More extensive testing might include a pelvic ultrasound and endometrial sampling to rule out other gynecological pathologies.

Bone Health
In athletes with LEA, DE, ED or amenorrhea of over 6 months, BMD should be measured by DXA. In the adolescent, DXA should include the whole body (head excluded) in addition to the lumbar spine. As athletes in weight-bearing sports should have 5-15% higher BMD than non-athletes a BMD Z-score < -1.0 SD warrants further attention. In the athlete population, low BMD is defined as a Z-score between -1.0 SD and -2.0 SD, together with a history of nutritional deficiencies, hypoestrogenism, stress fracture /or other secondary clinical risk factors for fracture. A value below -2.0 SD is considered as
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The recommended time interval to reassess BMD via DXA scan for athletes at risk, or who are being treated for low BMD is 12 months in adults and a minimum of 6 months in adolescents.⁹⁵

Quantitative computed tomography (QCT) provides information on bone geometry, with 3D imaging of both cortical and trabecular bone: axial QCT for the spine and hip, and peripheral QCT (pQCT) for the peripheral skeleton (distal radius and tibia).⁹⁶-⁹⁷ Quantitative Ultrasound (US) assesses bone quality parameters, such as stiffness and is sensitive to exercise-induced changes in bone health.⁹⁸ Frequently, stress fractures are not visualized on plain radiographs, and further imaging including nuclear bone scans, Computed Tomography and/or Magnetic Resonance Imaging is required.⁹⁹,¹⁰⁰

TREATMENT STRATEGIES OF RELATIVE ENERGY DEFICIENCY IN SPORT

Treatment Strategies for LEA

The treatment of LEA should involve an increase in energy intake, reduction in exercise or a combination of both. The only strategy to have received scientific scrutiny is the addition of an energy-rich supplement (e.g. liquid meal product) to habitual intake and a small reduction in, or introduction of a rest day to the weekly training program.⁹⁴-⁹⁶ Despite the small sample size, this intervention was successful¹⁰¹,¹⁰² however not in all studies¹⁰³ as this strategy may fail to address many underlying dietary and psychological factors. While developing a strategy to implement a diet of known and appropriate EA may be logical, it is usually impractical due to the challenges of measuring EA in the field. Therefore, a practical treatment approach to address LEA is to implement an eating plan that increases current energy intake by ~300-600 kcal/d (1.2-2.4 MJ/d) and addresses sub-optimal practices related to energy spread over the day and around exercise sessions, dietary composition and food-related stress.

Treatment Strategies for LEA associated Menstrual Dysfunction

In collegiate athletes, weight gain is the strongest predictor of recovery of normal menstrual function.¹⁰⁴-¹⁰⁶ Adequate protein and carbohydrate intake is recommended to restore liver glycogen to
facilitate LH pulsatility.\textsuperscript{31,107} The timeframe for the resumption of menses varies according to the severity of the energy deficiency and the duration of the menstrual dysfunction.\textsuperscript{105,108} Although oral contraceptives (OCs) may be considered for athletes requiring contraception,\textsuperscript{109} these may mask the LEA, menstrual dysfunction and perpetuate bone loss. Injectable depot medroxyprogesterone, another form of contraception, can cause amenorrhea therefore prolonged use can adversely affect BMD,\textsuperscript{110} and adolescent bone mass accrual,\textsuperscript{111} which is reversible to a certain extent upon discontinuation.\textsuperscript{112} Many physicians prescribe low dose OCs as hormone replacement in the amenorrheic athlete, however this intervention does not correct the etiological cause of relative energy deficiency and may compromise the attainment of peak bone density.\textsuperscript{113}

Treatment options to restore fertility may include increasing EA. Pharmacologic agents may be necessary to stimulate ovulation in luteal phase deficiency.\textsuperscript{27} Attention must be paid to infertility treatments identified in the WADA Prohibited List.\textsuperscript{114}

**Treatment Strategies to Optimize Bone Health**

Strategies to reverse bone loss in women with FHA parallel those used for amenorrheic anorexics.\textsuperscript{115} In the latter population, weight gain with or without the subsequent resumption of menses restores the coupling of bone formation and resorption\textsuperscript{116,117} and improves BMD.\textsuperscript{116} However full recovery may not be feasible, as bone microarchitecture is also impaired.\textsuperscript{118} Energy intake alone increases bone mass by 1-10\% in anorexics.\textsuperscript{117,119} It is essential to restore both the energy and estrogen-dependent mechanisms of bone loss in order to improve mineralization of trabecular bone and growth of cortical bone.\textsuperscript{41} Mechanical loading and high-impact sports are known to positively affect BMD\textsuperscript{120,121} as well as bone geometry.\textsuperscript{122,123} Programs of high-impact loading and resistance training should be implemented at least 2-3 days/week for athletes in non-weight bearing sports and/or those with decreased BMD.\textsuperscript{6}

The athlete diet should include 1500mg/day of calcium through dietary sources with supplementation if required.\textsuperscript{124} The Endocrine Society Guideline (2011) recommends maintaining Vitamin D [25(OH)D] blood levels above 32-50 ng/ml, with 1500-2000 IU/d of Vitamin D.\textsuperscript{125,126} Vitamin D deficiency is
common in northern latitudes, especially during winter when there are fewer hours of sunlight and among athletes who train indoors. Other factors include dark pigmented skin, and the use of sunscreen. A recent meta-analysis of Vitamin D supplementation found a positive effect in femoral and hip BMD, with no effect in the spine. Transdermal estradiol (given with cyclic progesterone) has shown some success in increasing BMD in anorexic patients. In some studies, combination OCs containing 20-35 micrograms of estradiol have maintained or improved BMD in amenorrheic athletes. However, use of the OCP in athletes with FHA have been reported to have a detrimental effect on BMD through the suppression of androgen secretion and cause premature closure of the epiphyses compromising growth of the long bones in adolescents.

Bisphosphonates, which inhibit the resorption of bone, are not recommended for women of reproductive age, as they are stored in bone for prolonged amounts of time and have been shown to be teratogenic. Other therapies including raloxifene (a selective estrogen receptor modulator or SERM), parathyroid hormone peptides, teriparatide and calcitonin, are also not approved for use in pre-menopausal women. Some novel potential therapies are in development, but clinical trials are lacking. These include Insulin-derived Growth Factor (a bone anabolic agent) and leptin which can be used to stimulate appetite thus effecting resumption of menses and subsequent improvement in BMD.

In males, as in females, detection and correction of any underlying pathology is essential, including testosterone therapy in men with hypogonadism and osteoporosis. Bisphosphonates may be used as monotherapy, as consolidative therapy after a course of teriparatide administration, or in combination with hormonal replacement. Denusomab and strontium ranelate also increase BMD in men with osteoporosis.

**Treatment Strategies for Psychological Sequelae**

If an athlete will not or cannot follow the treatment plan, a psychological factor is generally present. Athlete resistance to treatment usually increases with the severity of the eating problem. Treatment
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should be provided by a mental health professional knowledgeable about the management of EDs in athletes. The frequency, types, intensity, and duration of psychological treatment depend on the severity, chronicity, and the medical and psychological complications of the eating problem, as well as the co-morbid psychological disorders that often accompany such problems. Ideally, eating problems can be treated on an outpatient basis. Medical complications, risk of self-harm, and lack of progress in outpatient treatment indicate a need for more intensive treatment regimens including inpatient, residential, partial hospitalization, and intensive outpatient programs. Treatment usually is required for several months. Treatment modalities might include Cognitive Behavioral Therapy, Dialectical Behavior Therapy, or Family Based Therapy. Co-morbid conditions, such as depression, anxiety, and other psychological problems also need to be addressed. Pharmacotherapy may also be recommended; antidepressants are the class of medications most often prescribed.\textsuperscript{146}

**CLINICAL MODELS FOR SPORT PARTICIPATION AND RETURN TO PLAY**

Risk Assessment for Sport Participation

There are limited evidence-based guidelines to assist the athlete health care team in the assessment for sport participation clearance with RED-S. Based on the guidelines from the Norwegian Olympic Training Center\textsuperscript{147} and the collective expertise of the IOC Consensus group, a new model of criteria to assess risk for sport participation has been developed (Table 1). This model can be incorporated into the Periodic Health Examination (PHE). The criteria for this model are based on those used at the Norwegian Olympic Training Center, \textsuperscript{147} and also recommended by the IOC Body Composition, Health and Performance Working group.\textsuperscript{8}
### Table 1. Relative Energy Deficiency in Sport risk assessment model for sport participation (modified from Skårderud et al. 2012)\(^{147}\)

<table>
<thead>
<tr>
<th>HIGH RISK: NO START</th>
<th>MODERATE RISK: CAUTION</th>
<th>LOW RISK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RED LIGHT</strong></td>
<td><strong>YELLOW LIGHT</strong></td>
<td><strong>GREEN LIGHT</strong></td>
</tr>
<tr>
<td>• Anorexia nervosa and other serious eating disorders</td>
<td>• Prolonged abnormally low % body fat measured by DXA or anthropometry using The International Society for the Advancement of Kinanthropometry ISAK(^<em>) or non-ISAK approaches(^</em>)*</td>
<td>• Healthy eating habits with appropriate energy availability</td>
</tr>
<tr>
<td>• Other serious medical (psychological and physiological) conditions related to low energy availability</td>
<td>• Reduced BMD (either from last measurement or Z-score &lt; -1 SD), History of 1 or more stress fractures associated with hormonal /menstrual dysfunction and/or LEA</td>
<td>• Healthy BMD as expected for sport, age and ethnicity</td>
</tr>
<tr>
<td>• Extreme weight loss techniques leading to dehydration induced hemodynamic instability and other life threatening conditions.</td>
<td>• Abnormal menstrual cycle: FHA amenorrhea &gt; 6 months, Menarche &gt; 16 yrs, Abnormal hormonal profile in males</td>
<td>• Healthy musculoskeletal system</td>
</tr>
<tr>
<td>• Severe ECG abnormalities (i.e. bradycardia)</td>
<td>• Athletes with physical/psychological complications related to LEA/disordered eating; - ECG abnormalities - Laboratory abnormalities</td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
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<tr>
<td>---</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Prolonged relative energy deficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disordered eating behavior negatively affecting other team members</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of progress in treatment and/or non-compliance</td>
<td></td>
</tr>
</tbody>
</table>

*Sutton 2012* 148

**Jackson 1985** 149
Chapter 5. The IOC consensus statement:
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It is recommended that athletes in the “High Risk - Red Light” risk category should not be cleared to participate in sport. Due to the severity of their clinical presentation, sport participation may pose serious jeopardy to their health and may also distract the athlete from devoting the attention needed for treatment and recovery. These athletes should receive treatment using a written treatment contract (Appendix 1). Athletes in the “Moderate Risk - Yellow Light” risk category should be cleared for sport participation only with supervised participation and a medical treatment plan. Re-evaluation of the athlete’s risk assessment should occur at regular intervals of 1-3 months depending on the clinical scenario to assess compliance and to detect changes in clinical status.

Return to Play

Decision-making regarding RTP following time away for sport for recovery from injury and/or illness is based on the assessment of the athlete’s health and the requirements of his/her sport. Table 3 adapts Creighton’s RTP Model and the guidelines from the Norwegian group to the athlete with RED-S through the addition of RED-S specific criteria.

The RED-S Risk Assessment Model is adapted to aid clinicians’ decision making for determining an athlete’s readiness to return to sport. Following clinical reassessment utilizing the 3 step evaluation outlined in Table 2, athletes can be re-classified into the “High Risk - Red Light”, “Moderate Risk - Yellow Light” or “Low Risk - Green Light” categories. The RED-S Return to Play Model (Table 3) outlines the sport activity recommended for each risk category.
Table 2. The Relative Energy Deficiency in Sport Decision-based Return to Play Model (modified from Creighton et al. 2010)\textsuperscript{150}.

<table>
<thead>
<tr>
<th>STEPS</th>
<th>RISK MODIFIERS</th>
<th>CRITERIA</th>
<th>RED-S SPECIFIC CRITERIA</th>
</tr>
</thead>
</table>
| **STEP 1**
Evaluation of Health Status | MEDICAL FACTORS | Patient Demographics
Symptoms
Medical History
Signs
Laboratory Tests
Psychological Health
Potential Seriousness | Age, sex
see Yellow Light column (Table 1)
Recurrent dieting, menstrual health, bone health
Weight loss / fluctuations, weakness
Hormones, electrolytes, ECG, DXA
Depression, anxiety, disordered eating/ eating disorder
Abnormal hormonal & metabolic function
Stress fracture |
| **STEP 2**
Evaluation of Participation Risk | SPORT RISK MODIFIERS | Type of Sport
Position Played
Competitive Level | Weight sensitive, leanness sport
Individual vs. team sport
Elite vs. recreational |
| **STEP 3**
Decision Modification | DECISION MODIFIERS | Timing & Season
Pressure from Athlete
External Pressure
Conflict of Interest
Fear of Litigation | In/out of season, travel, environmental factors
Desire to compete
Coach, team owner, athlete family, sponsors
If restricted from competition |
Table 3. The Relative Energy Deficiency in Sport Return to Play Model (modified from Skårderud et al, 2012)

<table>
<thead>
<tr>
<th>HIGH RISK RED LIGHT</th>
<th>MODERATE RISK YELLOW LIGHT</th>
<th>LOW RISK GREEN LIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>• No competition</td>
<td>• May compete once medically cleared under supervision</td>
<td>• Full sport participation</td>
</tr>
<tr>
<td>• Supervised training allowed when medically cleared for adapted training</td>
<td>• May train as long as is following the treatment plan</td>
<td></td>
</tr>
<tr>
<td>• Use of written contract (see appendix 1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RECOMMENDATIONS TO ADDRESS RELATIVE ENERGY DEFICIENCY IN SPORT

The following recommendations are formulated based on a review of the scientific evidence and the collective expertise of the IOC Consensus group relating to the RED-S.

Athlete Entourage Recommendations

The athlete’s entourage can prevent RED-S through implementation of the following strategies:

- Educational programs on RED-S, healthy eating, nutrition, EA, the risks of dieting and how these affect health and performance
- Reduction of emphasis on weight, emphasizing nutrition and health as a means to enhance performance
- Development of realistic and health-promoting goals related to weight and body composition
- Avoidance of critical comments about an athlete’s body shape/weight
- Use of reputable sources of information.
- Promotion of awareness that good performance does not always mean the athlete is healthy.
- Encouragement and support of appropriate, timely, and effective treatment.

Health Care Professional Recommendations

Health Care professionals can decrease the health implications of RED-S through the following interventions:

- Identification of a multi-disciplinary athlete health support team including sports physician, nutritionist, psychologist, physiotherapist and physiologist.
- Education of the medical team in the detection and treatment of the RED-S
Chapter 5. The IOC consensus statement:
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- Implementation of the RED-S Risk Assessment Model in the PHE and the RED-S RTP Model.

Sport Organization Recommendations

Sport organizations such as International Federations, National Olympic Committees and National Sport Federations can prevent RED-S through the implementation of:

- Preventative educational programs
- Rule modifications/changes to address weight-sensitive issues in sport
- Policies for coaches on the healthy practice of managing athlete eating behavior, weight and body composition.

Research Recommendations

Research Institutions should focus on research and evaluation of:

- The etiology and treatment of athletes with RED-S including males, ethnic and disabled populations.
- Design and validation of tools to accurately measure EA in the clinical setting.
- The validation of screening tools and treatment programs such as the RED-S Risk Assessment Model and RED-S RTP Model.
The role of International Sports Federations in safeguarding the health and well-being of athletes

Lessons learned from FINA’s activities

REFERENCES


Chapter 5. The IOC consensus statement:
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Authors' 2015 additions to the IOC Consensus Statement:

Relative Energy Deficiency in Sport (RED-S)

In April 2014, the International Olympic Committee (IOC) published a Consensus Statement in the British Journal of Sports Medicine (BJSM) entitled “Beyond the Female Athlete Triad – Relative Energy Deficiency in Sport (RED-S)”\textsuperscript{1}. In reference to that Consensus Statement, Professor Mary Jane de Souza and colleagues published an editorial in the BJSM (July 2014).\textsuperscript{2} The editorial below expands on the original Consensus Statement and comments on the 2014 editorial by Professor Mary Jane de Souza and colleagues.

RELATIVE ENERGY DEFICIENCY IN SPORT (RED-S)

Albert Einstein, said: “The important thing is to never stop questioning.” A group of eleven IOC authors have called attention, as others in the past\textsuperscript{3,4}, to a problem that is wider and more complex than originally identified when the term ‘Female Athlete Triad’ (Triad or FAT) was first coined in 1992. Just as knowledge evolves, so too should ideas and constructs on how to address it.

Given the evolution of science since 1992, and to more accurately describe the clinical syndrome originally known as the Female Athlete Triad, the IOC introduced a more comprehensive, broader term: Relative Energy Deficiency in Sport.

“\textit{The syndrome of RED-S refers to impaired physiological functioning caused by relative energy deficiency, and includes but is not limited to impairments of metabolic rate, menstrual function, bone health, immunity, protein synthesis and cardiovascular health.}”

Our April 2014 Consensus statement identifies the etiological factor underpinning the syndrome as:
Chapter 6. Authors’ additions to the IOC consensus statement:

RED-S

“an energy deficiency relative to the balance between dietary energy intake and the energy expenditure required to support homeostasis, health and the activities of daily living, growth and sporting activities.”

We reaffirm the principle that the IOC Consensus Statement highlights about energy deficiency/low energy availability among exercising people. Professor De Souza and colleagues’ editorial criticises the use of the word “balance,” suggesting the IOC authors have confused the terms energy availability and energy balance. We used the term “balance” in the context of comparing two items which are not necessarily equal. To clarify, the underlying etiology of RED-S is the same as that which underpins the Triad – low energy availability. The reason that we chose the term RED-S - relative energy deficiency in sport is to recognise that low energy availability can occur in the presence of energy balance.

To clarify:

“the cause of the Relative Energy Deficiency in Sport is the scenario termed ‘low energy availability’, where an individual’s dietary energy intake is insufficient to support the energy expenditure required for health, function and daily living, once the costs of exercise and sporting activities are taken into account.”
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RELATIVE ENERGY DEFICIENCY in SPORT

Key Definitions:

Energy Balance \(^{33,34}\): Energy Balance is the amount of dietary energy added to or lost from the body’s energy stores after all of the body’s physiological systems have completed their work for the day. (EB= Energy intake – Total energy expenditure)

Energy Deficit: Energy deficit is the discrepancy in energy balance when dietary energy intake is less than total energy expenditure, such that energy is lost from the body’s energy stores and/or compensatory mechanisms take place to reduce total energy expenditure.

Energy Availability \(^{33,34}\): Energy availability is the amount of dietary energy remaining to support remaining metabolic systems in the body after the energy cost for a particular system has been removed: In the case of athletes, energy availability is the amount of energy remaining to support all other body functions after the energy expended in exercise and sporting activities is removed from energy intake. (EA = Energy intake – Energy expended in exercise)

Low Energy Availability \(^{33,34}\): Low energy availability occurs when an individual’s dietary energy intake is insufficient to support the energy expenditure required for health, function and daily living, once the cost of exercise and sporting activities is taken into account.

Relative Energy Deficiency: Relative energy deficiency connotes that low energy availability can occur even in the scenario where energy intake and total energy expenditure are balanced (i.e. there is no overall energy deficit).

Relative Energy Deficiency in Sport \(^1\): The syndrome of RED-S refers to impaired physiological functioning caused by relative energy deficiency, and includes but is not limited to impairments of metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health.
**LIMITATIONS OF THE TERMINOLOGY “Female Athlete Triad”— WHY IT’S OVERDUE FOR A REBRAND**

The understanding of the Triad has strengthened over the past three decades because people were brave enough to stand up and describe a problem with some apparent features that needed urgent and focused investigation. Parts of the original model have been updated over time with new knowledge, and the sports medicine and exercise science community have embraced this evolution rather than insisting that Triad be invalidated because the details have changed. In fact, if one applied a pedantic critique of the Triad, many of the criticisms levelled at RED-S could also apply to it:

- **a)** **Female:** scientific publications clearly demonstrate that relative energy deficiency also affects males\(^5\text{-}24\).

- **b)** **Athlete:** by identifying the “athlete” in the title, the Female Athlete Triad fails to account for recreational exercisers and dancers who would not identify themselves as athletes but who can develop relative energy deficiency.

- **c)** **Triad:**
  
  i. The literature describes many more than two negative outcomes of low energy availability, so it either is not really a triad or it ignores/undervalues these other issues.

  ii. According to many studies, athletes have 1 or 2 out of the 3 of the traditional components of the triad, so it is not a true triad.

  iii. De Souza and colleagues’ editorial states that it can continue to call the syndrome a triad because the three corners (low energy availability/ menstrual dysfunction/ poor bone health) are the most serious parts. However, it is unclear what criteria are used to justify this assessment and why other aspects of the health/performance impairments associated with low energy availability do not merit topline recognition.
iv. The term ‘Triad’ does not prioritise the key element. When the ‘Triad’ was first coined, investigators were not aware that energy deficiency was the key problem. Subsequently, Professor Anne Loucks and others have provided compelling data on the pre-eminence of energy deficiency as the causative element. Why confuse trainees, health professionals and athletes by referring to a ‘triad’ when the culprit is not osteoporosis, not amenorrhea (two elements of the ‘triad’ as coined in 1992) but energy deficiency? Hence the recommendation of ‘relative energy deficiency in sport (RED-S)’.

d) The Female Athlete Triad acronym (FAT): While researchers and clinicians involved in the work of Female Athlete Triad refer to it as “Triad,” many others refer to it as “FAT,” an unfortunate acronym.

e) Female Athlete Triad Model: The present model/diagram and description fail to portray the interrelatedness of all the factors, the concern about sub-clinical levels of presentation, and the concern if all three issues are not involved. Thus it does not accurately describe the complexity of the syndrome.

MALE ATHLETES ARE AFFECTED – IT’S IRREFUTABLE

Although most studies related to RED-S have been performed on female athletes, there is a growing body of evidence that the negative sequelae of low energy availability also occur in male athletes from leanness-demanding or weight category sports, and in scenarios of high volume training. In particular, these male athletes also have an increased risk of disordered eating, disruption of GnRH and LH pulsatility, as well as lower sex hormone levels, impaired reproductive function, decreased immunity, and impaired bone health.
It is certainly possible, as hypothesised in the DeSouza and colleagues’ editorial, that male athletes have a different set of issues, outcomes and modifying factors involved in these observations. However, the IOC authors believe that these health issues need attention, rather than be ignored because they seem less defined.

The original version of the Triad proposed that clinical outcomes of disordered eating, amenorrhea and osteoporosis were always involved. The subsequent published model now recognises that this may not be the case, and that we still need to be concerned about female athletes whose energy availability, menstrual function, and/or bone health are suboptimal, even if not yet a clinically recognised problem. So, why are we discounting problems for male athletes because of a hypothesis that they may not be as “serious” as those of females? Any level of suboptimal body function caused by inadequate energy intake is a potential issue worthy of study and needing the attention of athletes/coaches/professionals. As knowledge grows, the discussion and recommendations for different groups can evolve.

The hypothesis that low energy availability/energy deficiency is not as important for males because they do not have the same energetic cost of reproduction to defend, also raises questions about whether the Triad is problematic for females outside the reproductive age. Do we stop worrying about premenarcheal and postmenopausal females with low energy availability? If energy availability is low, it will reduce the capacity for some type of body function, activity and/or performance. Therefore, since energy deficiency and eating disorders seem to have many similar physiological and health impairing effects in men as they do in women, it is time to broaden the concept to include males as well as females. Indeed, the Olympic Charter, which documents the fundamental principles of Olympism, provides clear direction regarding human rights in sport; and in particular against discrimination on the basis of gender:
“The practice of sport is a human right. Every individual must have the possibility of practicing sport, without discrimination of any kind…..Any form of discrimination with regard to a country, or a person on grounds of race, religion, politics, gender or otherwise is incompatible with belonging to the Olympic Movement.”25 The Olympic Movement Medical Code goes even further, underscoring the obligation to avoid gender discrimination in the provision of medical care of athletes: “Athletes should receive such health care as appropriate to their needs….Services should be continuously available and accessible to all equitably, without discrimination.”26 The current IOC leadership has repeatedly underscored their commitment to the protection of athlete health (women and men).27

RED-S HEALTH AND PERFORMANCE CONSEQUENCES

There is always a challenge in developing a simple model for handling complex, multi-factorial problems. The RED-S conceptual models of potential Health and Performance Consequences of relative energy deficiency are designed for simplicity of understanding the main principle of the underpinning etiology of RED-S, which is placed in the centre of the ‘hub and spoke’ model. The conceptual models are also designed to show a plethora of physical, psychological and potential performance sequelae that develop as a result of energy deficiency, regardless of their relative importance. The chief purpose of the models is to serve as a clinical teaching tool for athletes and coaches to demonstrate the numerous health consequences of relative energy deficiency, as well as the performance consequences, which are priority for them.

The RED-S conceptual models are not designed to illustrate the complex interactions of physiological and psychological factors involved in the process nor the interconnectivity among the functions and mechanisms involved in the syndrome. Indeed, these synergistic and antagonistic process mechanisms are also not captured in the current Triad model 28. As knowledge of the interactions of the functional processes of RED-S advances, the IOC Consensus
Chapter 6. Authors' additions to the IOC consensus statement:

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Statement authors will embrace the expected evolution of the RED-S conceptual models of the Health and Performance Consequences.

Figure 1: Health Consequences of Relative Energy Deficiency in Sport (RED-S) showing an expanded concept of the Female Athlete Triad to acknowledge a wider range of outcomes and the application to male athletes (*Psychological consequences can either precede RED-S or be the result of RED-S) Adapted from Constantini 2002
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Figure 2: Potential Performance Effects of Relative Energy Deficiency in Sport (**Aerobic and anaerobic performance) Adapted from Constantini 2002

RED-S RISK ASSESSMENT AND RETURN TO PLAY MODELS

The RED-S ‘Red Light – Yellow Light – Green Light’ Risk Assessment and Return to Play (RTP) models are designed to take a complex clinical assessment and RTP decision making process and integrate them into a functional model that is both simple to understand by the athlete and the clinician, and is relatively easy to implement in the ‘real world’. The challenge of designing a functional model to better manage complex clinical scenarios arises in all areas of medicine. Clinicians want guiding principles to assist with medical management and harm minimisation. All models have limitations, but they are designed with latitude in the interpretation of an individual’s situation by experts, acknowledgement of mitigating factors, ongoing monitoring of the individual, and continual re-evaluation of the model.
The RED-S ‘Red Light – Yellow Light – Green Light’ Risk Assessment and Return to Play models were developed with this flexibility to allow clinicians in the field the ability to adapt the model to their particular athlete situation. For example, the specific length of “prolonged period with low energy availability” is not provided in the RED-S model because there are no studies indicating the time frame an athlete can experience energy deficit without compromising health and performance. However, it is the experience and belief of the IOC authors that treating clinicians’ knowledge of the sport-specific demands and case-specific parameters, combined with their clinical experience, is sufficient for them to be able to adapt their particular clinical scenario to the RED-S models to facilitate a safe RTP decision. In fact, the models presented in the IOC Consensus Statement for Risk Assessment and RTP have been developed and implemented for more than two years at the competitive level, for all ages and sport disciplines of athletes at the Norwegian Olympic Training Center. These models have already been demonstrated to be successful in practice.

The models were developed to be adaptable for both males and females. The endpoints identified as red light “high risk” criteria and the yellow light “caution” criteria all apply to both male and female athletes except for the two endpoints related to the menstrual cycle. Since there are many different methods to estimate body composition and the standard error of measurements can be high (as high as 5 % and higher for commonly used field methods if not standardized) depending on the method and standardization used, it is difficult to specify the lower limit of body fat for male and female elite athletes, even though the general guidelines recommend > 5 % body fat for men and 10 % for women.

To further support clinicians in the field with the management of RED-S athletes, the IOC authors have developed a RED-S Clinical Assessment Tool (RED-S CAT) modelled after the Sport
Concussion Assessment Tool (SCAT-3)\textsuperscript{32}, which is widely used in clinical practice. Like the original SCAT, the RED-S CAT is a starting point to facilitate clinical practice and to encourage further research and validation, and is expected to evolve over time as the body of science in the field grows.

**FUTURE DIRECTIONS**

The IOC authors of the Consensus Statement on RED-S recommend that the sports medicine and sport science communities gain an increased understanding and awareness of the broadened concept of RED-S. The RED-S conceptual models should be integrated into performance nutrition educational approaches, as they offer an opportunity for athletes and coaches to understand the broad scope of issues related to suboptimal eating practices. The RED-S CAT should be implemented globally to facilitate and improve the medical management of both male and female athletes.

Professor DeSouza and colleagues are correct that the body of published research on RED-S is not yet as robust as that on the Triad. Indeed, most of the Triad research was done AFTER the term was coined. It is a recommendation of the IOC authors, as written in the IOC Consensus paper, that the scientific experts in the field work collaboratively to further enhance our understanding of:

- The etiology and best treatment of athletes with RED-S, including males and females, able-bodied and disabled populations, and individuals of various races.
- The design and validation of tools to accurately measure energy availability in the clinical setting.
- The validation of screening tools (such as the RED-S CAT), prevention and treatment programs.
In summary, it is evident that the term ‘Female Athlete Triad’ is not only inaccurate, but also inadequate to describe the syndrome. As the underlying etiology is low energy availability, the coining of new, more comprehensive terminology ‘relative energy deficiency in sport’ (RED-S) is introduced by the IOC following a robust review and debate of the current science base. It is also time to acknowledge and address the health and performance of the male athlete who also suffers from RED-S. It is time for change.

“Progress is not possible without change.” George Bernard Shaw
REFERENCES


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26. Care and Treatment: # 5.1. in The Olympic Movement Medical Code 2009


The IOC Relative Energy Deficiency in Sport
Clinical Assessment Tool (RED-S CAT)


In April 2014, the International Olympic Committee (IOC) published a Consensus Statement in the British Journal of Sports Medicine (BJSM) entitled “Beyond the Female Athlete Triad—Relative Energy Deficiency in Sport (RED-S)”. To assist sports medicine professionals working in clinical sports medicine with the practical screening and management of the RED-S athlete, the IOC authors have developed a Clinical Assessment Tool – the RED-S CAT.

It is well known that the utility of scientific knowledge is limited at a practical level and that implementing effective interventions in the real life sport setting are challenging. As in all areas of medicine, there is now attention in sports medicine to the growing field of knowledge translation. Effective translation of the science into practical usable formats is necessary to ensure that athlete care is both evidence-based and effective.

Sports medicine clinicians utilize guiding principles and various models to assist with the medical management and harm minimisation in their course of their care of athletes. The RED-S ‘Red Light – Yellow Light – Green Light’ Risk Assessment and Return to Play (RTP) models are designed to take a complex clinical assessment and RTP decision making process and integrate them into a functional model that is both simple to understand by the athlete and the clinician, and is relatively easy to implement in the ‘real world’. Effective sports medicine models are designed with latitude to accommodate the interpretation of an athlete’s unique situation by the treating clinician, acknowledgement of mitigating factors, ongoing monitoring of the individual, and continual re-evaluation of the model. The RED-S ‘Red Light – Yellow Light – Green Light’ Risk Assessment and Return to Play models were developed with this flexibility to allow clinicians in
the field the ability to adapt the model to their particular athlete situation. These models enable the treating clinicians to apply their knowledge of the sport-specific demands and case-specific parameters, combined with their clinical experience, within the flexible parameters of the model. The models were developed to be adaptable for both males and females. The endpoints identified as red light “high risk” criteria and the yellow light “caution” criteria all apply to both male and female athletes except for the two endpoints related to the menstrual cycle. These models have been implemented successfully since 2012 at the competitive level, for all ages and sport disciplines of athletes at the Norwegian Olympic Training Center. The IOC authors recommend that the RED-S conceptual models should be integrated into performance nutrition educational approaches, as they offer an opportunity for athletes and coaches to understand the broad scope of issues related to suboptimal eating practices.

To facilitate this recommendation, the IOC authors have developed a RED-S Clinical Assessment Tool (RED-S CAT) modelled after the Sport Concussion Assessment Tool (SCAT-3), which is widely used in clinical practice. Utilization of the RED-S CAT will assist clinicians in the field with the screening of athlete populations at risk and the management of return to play decisions of RED-S athletes. Like the original SCAT, the RED-S CAT is designed to facilitate clinical practice and to encourage further research and validation. It is expected that the RED-S CAT will evolve over time as the body of science in the field grows.

The RED-S CAT should be implemented globally to facilitate and improve the medical management of both male and female athletes with RED-S.
What is the RED-S CAT?

The RED-S CAT is a clinical assessment tool for the evaluation of athletes/active individuals suspected of having relative energy deficiency and for guiding return to play decisions. The RED-S CAT is designed for use by a medical professional in the clinical evaluation and management of athletes with this syndrome. The RED-S CAT is based on the IOC Consensus Statement on RED-S, 2014. This tool may be freely copied in its current form for use by sport organizations and the athlete medical team. Alterations to the tool or reproduction for publication purposes require permission from the International Olympic Committee.

NOTE: The diagnosis of RED-S is a medical diagnosis to be made by a trained health care professional. Clinical management and return to play decisions for athletes with RED-S should occur under the guidance of an experienced sports medicine team.

What is Relative Energy Deficiency in Sport?

The syndrome of RED-S refers to impaired physiological functioning caused by relative energy deficiency, and includes but is not limited to impairments of metabolic rate, menstrual function, bone health, immunity, protein synthesis, and cardiovascular health.

The cause of RED-S is the scenario termed “low energy availability”, where an individual’s dietary energy intake is insufficient to support the energy expenditure required for health, function, and daily living, once the cost of exercise and sporting activities is taken into account.

The potential health consequences of RED-S are depicted in the RED-S conceptual model (See Figure 1). Psychological problems can be both the result of and the cause of RED-S.

Screening for RED-S

The screening and diagnosis of RED-S is challenging, as symptomatology can be subtle. A special focus on the athlete at risk is needed. Although any athlete can suffer from RED-S, those at particular risk are those in judged sports with an emphasis on the aesthetic or appearance, weight category sports, and endurance sports. Early detection is of importance to maintain and improve performance and prevent long-term health consequences.

Screening for RED-S can be undertaken as part of an annual Periodic Health Examination and when an athlete presents with Disordered Eating (DE)/Eating Disorders (ED), weight loss, lack of normal growth and development, endocrine dysfunction, recurrent injuries and illnesses, decreased performance/performance variability or mood changes.
RED-S Risk Assessment Model for sport participation

This model can be incorporated into the Periodic Health Examination. Depending on the findings on history and physical examination, the athlete is classified into one of the 3 following categories: *Red Light*: High risk. **Yellow Light**: Moderate risk. *Green Light*: Low risk.

### HIGH RISK: NO START RED LIGHT
- Anorexia nervosa and other serious eating disorders
- Other serious medical (psychological and physiological) conditions related to low energy availability
- Use of extreme weight loss techniques leading to dehydration induced hemodynamic instability and other life threatening conditions.

### MODERATE RISK: CAUTION YELLOW LIGHT
- Prolonged abnormally low % body fat measured by DXA* or anthropometry
- Substantial weight loss (5–10% body mass in one month)
- Attenuation of expected growth and development in adolescent athlete

### LOW RISK: GREEN LIGHT
- Appropriate physique that is managed without undue stress or unhealthy diet/exercise strategies
- Healthy eating habits with appropriate EA
- Healthy functioning endocrine system
- Healthy bone mineral density as expected for sport, age and ethnicity
- Healthy musculoskeletal system

**Notes on diagnostic tools for Low EA:**

Although low EA is a key factor in RED-S, at the present time there is no standardised protocol for undertaking an assessment of EA in free-living athletes. Some sports nutrition experts may have developed tools to monitor EA in which they have confidence, and may use these to screen for problems or guide dietary counselling. However, a universal recommendation to measure EA is unsure in the absence of a protocol that is sensitive, reliable, time-efficient and cost-effective.

### Redefinition of the sport participation risk category

A new risk category is introduced: *Low Risk – Green Light*: full sport participation.

### Return to Play Model

Following clinical reassessment utilizing the 3 step evaluation outlined above, athletes can be re-classified into the *High Risk – Red Light*, **Moderate Risk – Yellow Light** or *Low Risk – Green Light* categories. The RED-S Risk Assessment Model is adapted to aid clinicians’ decision making for determining an athlete’s readiness to return to sport/physical activity.

### Treatment of Relative Energy Deficiency in Sport (RED-S)

Athletes categorized in the red light and yellow light zones should receive medical evaluation and treatment. The treatment of RED-S should be undertaken by a team of health professionals including a sports medicine physician, sports dietician, exercise physiologist, athletic therapist or trainer, sports psychologist/sports psychiatrist as needed. Patient confidentiality must be maintained. Treatment should focus on correcting the relative energy deficit through increasing energy intake and/or decreasing energy output. Intake of nutrients and other vitamins should follow established guidelines. Repeat assessment of BMD should occur at intervals of 6–12 months, depending on clinical presentation and initial values.

The use of an athlete contract is also recommended. (See Appendix)

### Sport Participation based on Risk Category

**High Risk – Red Light**: no clearance for sport participation.

Due to the severity of his/her clinical presentation, sport participation may pose serious jeopardy to his/her health and may also distract the athlete from devoting the attention needed for treatment and recovery.

**Moderate Risk – Yellow Light**: clearance for sport participation only with supervised participation and a medical treatment plan. Re-evaluation of the athlete’s risk assessment should occur at regular intervals of 1–3 months depending on the clinical scenario to assess compliance and to detect changes in clinical status.

**Low Risk – Green Light**: full sport participation.
APPENDIX

Relative Energy Deficiency in Sport (RED-S) Treatment Contract

RED-S Treatment Contract for ________________________________

Multidisciplinary Team:
■ (Physician) ________________________________
■ (Psychotherapist/Psychiatrist) ________________________________
■ (Exercise physiologist) ________________________________
■ (Dietitian) ________________________________
■ (Other) ________________________________

Requirements
Meet with:
■ The psychotherapist at intervals recommended by the health professional treatment team
■ The dietitian at intervals recommended by the health professional treatment team
■ The physician at intervals recommended by the health professional treatment team
■ Follow daily meal plan developed by the health professional treatment team
■ Follow the adapted training plan developed by the health professional treatment team
■ If underweight, weight gain expected to be __________ kg per week/weight stable within week __________
■ If underweight, must achieve minimal acceptable body weight/fat of __________ kg/percent by __________
■ Regular weigh-in at the following time intervals of __________ week(s)
■ After this date, __________ (dd/mm/yyyy), must maintain weight and % fat at or above minimal acceptable body weight/fat mass of __________ (kg/%)
■ Other ________________________________

If ALL requirements are met and the eating behavior (and other severe conditions) are normalized the Team Physician will decide if cleared for competition.

I, ________________________________ have read this contract and all of my questions were answered.

Athlete Name ________________________________ Athlete Signature ________________________________ Date ________________________________

Team Physician Name ________________________________ Team Physician Signature ________________________________ Date ________________________________

References

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CHAPTER 8

The role of International Sport Federations in the protection of the athlete’s health and promotion of sport for health of the general population

ABSTRACT

Objective
To determine the priorities and activities of International Sport Federations (IFs) with respect to the promotion of health in their sport and for the general population.

Methods
All 35 IFs participating in Olympic Games in 2014 or in 2016 were asked to rate the importance of 10 indicated topics, and to report their programmes, guidelines, or research activities on 16 health-related topics using an on-line questionnaire (response rate 97%).

Results
On average, the “fight against doping” had the highest priority followed by “health of their elite athlete” and “image as a safe sport”. The topics with the lowest importance ratings were “health of their recreational athlete”, “increasing the number of recreational athletes”, and “health of the general population”. All except one IF reported to have health-related programmes/guidelines/research activities; most IFs had 7 or 8 of the listed activities. Eight IFs (23.5%) stated to have activities for “prevention of chronic diseases in the general population” but only FIFA and FINA reported related projects.

Conclusion
IFs aimed to protect the health of their elite athletes through a variety of activities, however the health and number of their recreational athletes was of low importance for them. Thus, IFs are missing an important opportunity to increase the popularity of their sport, and to contribute to the health of the general population by encouraging physical activity through their sport. FIFA’s “Football for Health” and FINA’s “Swim for all” projects should serve as role models.
INTRODUCTION

The protection of the health of the athlete is embedded in the Olympic Movement Medical Code (OMMC) which governs the actions of the medical committees of the International Sports Federations (IFs): “The Olympic Movement, in accomplishing its mission, should encourage all stakeholders to take measures to ensure that sport is practised without danger to the health of the athletes ... it encourages those measures necessary to protect the health of participants and to minimise the risks of physical injury and psychological harm.”¹

According to the Olympic Charter, the IOC and the IFs have an obligation:

“9. to encourage and support measures protecting the health of athletes,
12. to encourage and support the development of sport for all.”²

In translating the Olympic Charter and the OMMC into action, the IOC and several IFs have developed activities for protecting the health of their athlete. Almost ten years ago, Fuller & Drawer published a theoretical framework on the application of risk management in sport.³ Cognisant of the health risks of sport participation, IFs have the responsibility to identify the health risks inherent to participation in their specific sport, and to respond to these risks through the development and implementation of measures to decrease and manage the health risks so as to reach an acceptable level of risk for athlete participation.³

In 1998 FIFA (see Table 1 for IFs’ acronyms) started as the first IF to systematically survey all injuries incurred in its competition.⁴ During the Olympic Games (OG) in 2004, injuries were recorded in all team sports.⁵ IAAF and FINA were the first IFs for individual sports to introduce injury surveillance in their World Championships 2007/2009.⁶ ⁷ The IOC included all athletes in their injury surveillance project at the OG in 2008.⁸ The IOC injury surveillance protocol ⁹ was expanded to include also illnesses in the Winter OG 2010¹⁰ and Summer OG 2012¹¹. In order to
standardise and encourage injury surveillance studies in their sports, several IFs have published consensus statements on injury definitions and data collection, such as football, rugby, tennis, horse racing, cricket and athletics.\textsuperscript{12-17}

Sports injuries can be prevented by different interventions, such as exercise-based programmes, rules and regulation as well as the promotion of Fair Play.\textsuperscript{18,19} Pre-participation/periodic medical examinations are another means aimed at protecting the health of the athlete. FIFA introduced a pre-competition medical assessment (PCMA) to all players of its World Cup in 2006,\textsuperscript{20} and subsequently to female and youth players \textsuperscript{21} and referees.\textsuperscript{22,23} The PCMA is now mandatory for all players participating in FIFA World Cups. The IOC published a Consensus Statement on the periodic health evaluation of elite athletes in 2009.\textsuperscript{24} In addition, specific recommendations on the prevention of sudden cardiac death in sport have been published.\textsuperscript{25-27}

Other important health-related topics in elite sport addressed by IFs and the IOC are nutrition/hydration,\textsuperscript{28-30} asthma,\textsuperscript{31} concussion,\textsuperscript{32-35} female athlete triad,\textsuperscript{36} hot environment,\textsuperscript{37} 38 altitude,\textsuperscript{38,39} gender reassignment,\textsuperscript{40} age determination,\textsuperscript{41-43} prevention of sexual abuse and harassment,\textsuperscript{44} and the fight against doping.\textsuperscript{45} Using the example of FIFA, Fuller et al.\textsuperscript{18} demonstrated how an IF uses a risk management framework to identify, quantify, mitigate and communicate the risks of injury and illnesses in its sport.

Little is known on the post-career life of top athletes and long-term consequences of elite sport. Retired football players, for example, have a higher rate of osteoarthritis in the lower extremity joints than the general population.\textsuperscript{46} Former male elite Finnish athletes in endurance, power and team sports had a greater risk of hospitalization for the treatment of musculoskeletal disorders in comparison to an age-matched non-former elite athlete control group.\textsuperscript{47} This athlete cohort, however, had an improvement in life expectancy,\textsuperscript{48} and less hospitalizations for non-communicable diseases (NCDs) such as respiratory disease, heart disease and cancer than the control group.\textsuperscript{47}
The WHO has classified insufficient physical activity (PA) as the fourth leading independent risk factor for the development of NCDs after hypertension, tobacco use and elevated blood glucose. Low levels of PA alone are responsible for 3.2 million or 5.5% of all deaths per year. Insufficient PA in children is associated with a higher incidence of hypertension, obesity and the metabolic syndrome. Participation in regular PA has well established health benefits for the general population through the reduction in the risk of premature death from NCDs, such as diabetes mellitus, coronary artery disease, colon and breast cancer, obesity, and hypertension. There is also evidence for prescribing PA in the treatment of type 1 and 2 diabetes, dyslipidemia, hypertension, obesity, heart and pulmonary diseases, muscle, bone and joint diseases and cancer, and depression.

Sport as the gatekeeper to PA has the ability to participate in the prevention of the epidemic of NCDs. In their paper entitled ‘Achieving the Millennium Development Goals’, the United Nations Inter-Agency Task Force on Sport for Development and Peace, reinforces the importance of sport in the prevention of NCDs: “Participation in sport has significant physical benefits, contributing to people’s ability to lead long and healthy lives, improving well-being, extending life expectancy and reducing the likelihood of several major non-communicable diseases.” Consequently, IFs should expand their mandate from protecting the health of their athletes to using their sport to improve the health of the general population.

FIFA started in 2007 to develop, test and implement a football-based health education programme “FIFA 11 for Health” to reduce risk factors for communicable and non-communicable diseases. In 2010 the IOC signed a Memorandum of Understanding with the WHO agreeing “to join efforts and to co-operate ... to promote healthy lifestyles, PA and sport among the communities.” and published two related consensus statements: The Consensus Statement on the fitness and health of children through sport identifies the health risks of physical inactivity in the global youth population and outlines recommendations for the world of sport and governmental organizations to address the issue. The Consensus Statement on prevention and
management of chronic disease focuses on the development of a strategy to prevent and treat NCDs by challenging and mobilizing the sport and exercise medicine community to action.\textsuperscript{58}

In summary, IFs have the responsibility to protect the health of their athletes and should promote PA via their sport to improve the health of the global population. The objective of the present study is, thus, to determine the current priorities and activities of IFs with respect to the promotion of health in their athletes and in the global population.

METHODS

The Association for Summer Olympic International Federations and the Association of Olympic International Winter Federations contacted all IFs participating in the OG in 2014 or in 2016 (Table 1) by email to the Secretary-General/Executive Director with a copy to the Chair of the IF Sports Medicine Committee. The IFs were requested to complete a survey on protection of their athlete’s health and promotion of their sport. The survey started with an introductory note, and the request for contact information to ensure the validity of the respondent. The IF was then asked to rate the importance of a list of eleven topics (Table 2) on a five-point scale from “\textit{not important}” to “\textit{top priority}”, and to report whether or not they have any programme(s)/guidelines(s)/research activities with regard to 16 health-related topics (Table 3), and if so, to provide details about their particular programme or activity in writing. Both lists were developed by the authors (AJ and MM) based on the review of the literature outlined in the introduction. Both lists of topics provided the option to add “\textit{others}”. Confidentiality of the data was maintained through password protection of the access to the results on the secure website. The IFs were given a two-week period of time to respond, then email reminders were sent to encourage participation. Details on the characteristics of the 35 IFs (Table 1) were gathered from the IOC website and the homepages of the IFs as well as from the publications of injury surveillance study during the OG in 2010 and 2012.\textsuperscript{10, 11} Data were processed using Excel and SPSS. Statistical methods applied were frequencies, cross-tabulations and chi2-test. Significance was accepted at $p < 0.05$. 

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RESULTS

Characteristics of International Sports Federations
The characteristics of the 35 IFs are described in Table 1. The oldest IFs were founded in 1892 (FIVB, ISU), the youngest (IGF) in 2010. The first modern OG in 1896 included athletics, cycling, gymnastics, fencing, shooting, swimming, weight lifting and wrestling. Rugby and golf will debut at the OG 2016 in Rio de Janeiro. The number of National Federations as an indicator of size and of popularity of the sport varied from 213 (FIBA) to 50 (WCF). The number of employees of the IFs ranged from 3 (IGF) to 400 employees (FIFA). Seven IFs represent team sports, 28 individual sports, and FINA includes both. The 35 IFs varied in the number of athletes participating in the OGs 2012/2010: five IFs (15%) were represented by over 500 registered athletes, eight (24%) by 351-500 athletes, nine (27%) by 201-350 athletes, and eleven (33%) by less than 201 athletes. All except one IF participated in the present study.
Table 1: Characteristics of International Sports Federations (IFs) participating in the Olympic Games (OG) in 2014 or in 2016

<table>
<thead>
<tr>
<th>IF</th>
<th>Sport</th>
<th>Year IF founded</th>
<th>No. of National Federations</th>
<th>N of IF’s Employees</th>
<th>Individual / Team sport</th>
<th>Year of 1st OG</th>
<th>Summer/Winter</th>
<th>Athletes at OG 2010/2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>FINA</td>
<td>Aquatics</td>
<td>1908</td>
<td>203</td>
<td>24</td>
<td>I / T</td>
<td>1896</td>
<td>S</td>
<td>1,431</td>
</tr>
<tr>
<td>FITA</td>
<td>Archery</td>
<td>1931</td>
<td>150</td>
<td>14</td>
<td>I</td>
<td>1931</td>
<td>S</td>
<td>128</td>
</tr>
<tr>
<td>IAAF</td>
<td>Athletics</td>
<td>1912</td>
<td>212</td>
<td>70</td>
<td>I</td>
<td>1896</td>
<td>S</td>
<td>2,079</td>
</tr>
<tr>
<td>BWF</td>
<td>Badminton</td>
<td>1934</td>
<td>179</td>
<td>14</td>
<td>I</td>
<td>1992</td>
<td>S</td>
<td>164</td>
</tr>
<tr>
<td>FIBA</td>
<td>Basketball</td>
<td>1932</td>
<td>213</td>
<td>44</td>
<td>T</td>
<td>1936</td>
<td>S</td>
<td>287</td>
</tr>
<tr>
<td>IBU</td>
<td>Biathlon</td>
<td>1998</td>
<td>67</td>
<td></td>
<td>I</td>
<td>1960</td>
<td>W</td>
<td>202</td>
</tr>
<tr>
<td>FIBT</td>
<td>Bobsleigh</td>
<td>1923</td>
<td>62</td>
<td></td>
<td>I</td>
<td>1924</td>
<td>W</td>
<td>206</td>
</tr>
<tr>
<td>AIBA</td>
<td>Boxing</td>
<td>1946</td>
<td>195</td>
<td>15</td>
<td>I</td>
<td>1904</td>
<td>S</td>
<td>283</td>
</tr>
<tr>
<td>ICF</td>
<td>Canoe</td>
<td>1924</td>
<td>150</td>
<td>7</td>
<td>I</td>
<td>1936</td>
<td>S</td>
<td>332</td>
</tr>
<tr>
<td>WCF</td>
<td>Curling</td>
<td>1966</td>
<td>50</td>
<td>35</td>
<td>I</td>
<td>1924</td>
<td>W</td>
<td>100</td>
</tr>
<tr>
<td>UCI</td>
<td>Cycling</td>
<td>1900</td>
<td>170</td>
<td>64</td>
<td>I</td>
<td>1896</td>
<td>S</td>
<td>401</td>
</tr>
<tr>
<td>FEI</td>
<td>Equestrian</td>
<td>1912</td>
<td>132</td>
<td>65</td>
<td>I</td>
<td>1912</td>
<td>S</td>
<td>199</td>
</tr>
<tr>
<td>FIE</td>
<td>Fencing</td>
<td>1913</td>
<td>147</td>
<td>9</td>
<td>I</td>
<td>1896</td>
<td>S</td>
<td>246</td>
</tr>
<tr>
<td>FIFA</td>
<td>Football</td>
<td>1904</td>
<td>209</td>
<td>400</td>
<td>T</td>
<td>1908</td>
<td>S</td>
<td>509</td>
</tr>
<tr>
<td>IGF</td>
<td>Golf</td>
<td>2010</td>
<td>132</td>
<td>3</td>
<td>I</td>
<td>2016</td>
<td>S</td>
<td>283</td>
</tr>
<tr>
<td>FIG</td>
<td>Gymnastics</td>
<td>1921</td>
<td>133</td>
<td>26</td>
<td>I</td>
<td>1896</td>
<td>S</td>
<td>323</td>
</tr>
<tr>
<td>IHF</td>
<td>Handball</td>
<td>1946</td>
<td>167</td>
<td>18</td>
<td>T</td>
<td>1936</td>
<td>S</td>
<td>349</td>
</tr>
<tr>
<td>FIH</td>
<td>Hockey</td>
<td>1924</td>
<td>124</td>
<td>14</td>
<td>T</td>
<td>1908</td>
<td>S</td>
<td>388</td>
</tr>
<tr>
<td>IIHF</td>
<td>Ice Hockey</td>
<td>1908</td>
<td>72</td>
<td></td>
<td>T</td>
<td>1924</td>
<td>W</td>
<td>444</td>
</tr>
<tr>
<td>IJF</td>
<td>Judo</td>
<td>1951</td>
<td>201</td>
<td>20</td>
<td>I</td>
<td>1964</td>
<td>S</td>
<td>383</td>
</tr>
<tr>
<td>FIL</td>
<td>Luge</td>
<td>1957</td>
<td>53</td>
<td></td>
<td>I</td>
<td>1964</td>
<td>W</td>
<td>188</td>
</tr>
<tr>
<td>UIPM</td>
<td>Modern Pentathlon</td>
<td>1948</td>
<td>55</td>
<td>4</td>
<td>I</td>
<td>1912</td>
<td>S</td>
<td>72</td>
</tr>
</tbody>
</table>

T = team sport (defined by the International Team Sport Federation Committee as two opposing groups of players on the field of play at the same time)
I = individual sport
W = Olympic winter sport
S = Olympic summer sport
Importance of health and promotion of sport for IFs

The IFs’ ratings of the perceived importance of the 10 indicated topics are presented in Table 2. The ‘fight against doping’ had on average the highest priority, being ranked as “important” or higher by all IFs and as a “top priority” by 70%. The next two topics in order of ranked importance were “health of elite athletes” and “image as a safe sport”; both classified as a “top priority” by more than half (55.9%) of the IFs and “very important” by further 38.2% resp. 35.3%. In descending order of importance “top performance of athletes in your sport”, “image as an enjoyable PA”, “increasing the number of spectators” and “increasing the number of elite athletes” followed. On average, the lowest importance for the IFs was the “health of the recreational athlete”, “increasing the number of recreational athletes”, and the “health of the general population”.

Five IFs (14.7%) rated none of the listed health topics as “top priority” for their IF. Two IFs rated all topics “very important”, one IF all as “important”, one all either “important” or “very important”, and one between “very” and “less important”. Eight IFs rated five topics as “top priority”; the maximum number of top priorities was seven (by 2 IFs).

The importance of health topics did not differ between summer and winter sport IFs, nor between individual versus team sport IFs, except for “increasing the number of recreational athletes” (being a higher priority for team sport IFs; p=0.018). Also no statistically significant relations were found between the importance ratings and the numbers of participating athletes at the OG or the number of employees of the IFs. Seven IFs gave free text answers on “others”, mostly repetition of topics already mentioned; in addition “research” and “prevention of drowning” were listed each by one IF.
### Table 2: Number (%) of 34 IFs’ rating of the importance of various topics for their federation

<table>
<thead>
<tr>
<th>How important are the following topics for your federation?</th>
<th>Not Important n (%)</th>
<th>Less Important n (%)</th>
<th>Important n (%)</th>
<th>Very Important n (%)</th>
<th>Top Priority n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image as a safe sport</td>
<td>0</td>
<td>0</td>
<td>3 (8.8)</td>
<td>12 (35.3)</td>
<td>19 (55.9)</td>
</tr>
<tr>
<td>Image as an enjoyable physical activity</td>
<td>0</td>
<td>3 (9.1)</td>
<td>5 (14.7)</td>
<td>15 (44.1)</td>
<td>11 (32.4)</td>
</tr>
<tr>
<td>Top performance of athletes in your sport</td>
<td>0</td>
<td>0</td>
<td>4 (11.8)</td>
<td>19 (55.9)</td>
<td>11 (32.4)</td>
</tr>
<tr>
<td>Health of your elite athlete</td>
<td>0</td>
<td>0</td>
<td>2 (5.9)</td>
<td>13 (38.2)</td>
<td>19 (55.9)</td>
</tr>
<tr>
<td>Health of recreational athletes in your sport</td>
<td>0</td>
<td>4 (12.1)</td>
<td>11 (32.4)</td>
<td>9 (26.5)</td>
<td>10 (29.4)</td>
</tr>
<tr>
<td>Health of the general population</td>
<td>3 (9.1)</td>
<td>7 (21.2)</td>
<td>10 (29.4)</td>
<td>10 (29.4)</td>
<td>4 (11.8)</td>
</tr>
<tr>
<td>Increasing the number of elite athletes</td>
<td>0</td>
<td>1 (3.0)</td>
<td>11 (32.4)</td>
<td>18 (52.9)</td>
<td>4 (11.8)</td>
</tr>
<tr>
<td>Increasing the number of recreational athletes</td>
<td>0</td>
<td>4 (12.1)</td>
<td>10 (29.4)</td>
<td>18 (52.9)</td>
<td>2 (5.9)</td>
</tr>
<tr>
<td>Increasing the number of spectators</td>
<td>0</td>
<td>2 (6.1)</td>
<td>7 (20.6)</td>
<td>16 (47.1)</td>
<td>9 (26.5)</td>
</tr>
<tr>
<td>Fight against doping</td>
<td>0</td>
<td>0</td>
<td>4 (11.8)</td>
<td>6 (17.6)</td>
<td>24 (70.6)</td>
</tr>
</tbody>
</table>

**IF’s programmes/ guidelines/ research activities on health-related topics**

Only one (2.9%) IF responded that they had no health related programmes/guidelines/research activities. All, except this IF, stated to have activities regarding “first aid (e.g. on pitch physician, AED)”. The second most common health related activities were “injury surveillance during championships” and “prevention by regulation for equipment/venues” (both 85.3%), followed by “nutrition/hydration”, “environmental conditions (e.g. temperature, altitude)”, “injury prevention by exercise-based programmes” and “pre-participation medical examination”. Eight (23.5%) IFs had activities related to “Prevention of chronic diseases in the general population”. The least common activities of the responding IFs were “mental health of their athletes”, “post elite career management” and “training/competing during pregnancy”. For further details see Table 3.

Except the one IF with none of the listed health-related activities and the one with all of them, the number of activities ranged between 4 and 13. Most IFs stated to have either seven (20.6%)
or eight (14.7%) activities. Eight IFs stated “yes” on the question on other activities, but only seven specified them. Three referred to health of the population through sport and one each “Medical Guide”, “Instructors Formation Programmes”, “seminar and congress”, “Health Certificate”.

Significant differences between team and individual sports IFs (FINA excluded) were found for “injury prevention by exercise-based programmes” (p<.05, all team sports vs. 50% of individual sports), “injury prevention by Fair Play” (p<.05, 6 of 7 teams sports vs. 34.6% of individual sports), “Pre-participation medical examination” (p<.05, all team sports vs. 42.3% of individual sports). No significant difference between winter and summer sport IFs or with regard to size of the IFs (based on number of athletes participating in the OG or on the numbers of employees) was found.
Table 3: Number and percentage of 34 IFs’ reporting to have programs, guidelines, or research activities on the indicated topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury surveillance during championships of your IF</td>
<td>29</td>
<td>85.3</td>
</tr>
<tr>
<td>Injury prevention by exercise-based programmes</td>
<td>21</td>
<td>61.8</td>
</tr>
<tr>
<td>Injury prevention by Fair Play campaigns or similar</td>
<td>15</td>
<td>44.1</td>
</tr>
<tr>
<td>Injury prevention by regulation for equipment / venues</td>
<td>29</td>
<td>85.3</td>
</tr>
<tr>
<td>Environmental conditions (e.g. temperature, altitude)</td>
<td>24</td>
<td>70.6</td>
</tr>
<tr>
<td>Pre-participation medical examination</td>
<td>19</td>
<td>55.9</td>
</tr>
<tr>
<td>Return-to-play after injury</td>
<td>13</td>
<td>38.2</td>
</tr>
<tr>
<td>First aid (e.g. on pitch physician, AED)</td>
<td>33</td>
<td>97.1</td>
</tr>
<tr>
<td>Nutrition / hydration</td>
<td>25</td>
<td>73.5</td>
</tr>
<tr>
<td>Rest days between competitions</td>
<td>13</td>
<td>38.2</td>
</tr>
<tr>
<td>Mental health of your athletes</td>
<td>5</td>
<td>14.7</td>
</tr>
<tr>
<td>Training/competing during pregnancy</td>
<td>4</td>
<td>11.8</td>
</tr>
<tr>
<td>Disorders of sexual development</td>
<td>9</td>
<td>26.5</td>
</tr>
<tr>
<td>Other medical conditions (e.g. female athlete triad, concussion)</td>
<td>13</td>
<td>38.2</td>
</tr>
<tr>
<td>Post elite career management</td>
<td>4</td>
<td>11.8</td>
</tr>
<tr>
<td>Prevention of chronic diseases in the general population</td>
<td>8</td>
<td>23.5</td>
</tr>
</tbody>
</table>

DISCUSSION
To the best of our knowledge this is the first study on the priorities and activities of IFs in the area of protection of the athlete’s health and promotion of health in the general population. The survey cohort was intentionally addressed to the Olympic IFs, thus the results are limited to this cohort. Inherent in survey format are the potential for self-report bias and the missing evaluation of the quality of the activities/programmes. Differences between winter vs. summer / individual vs. team sports IFs should be interpreted with caution due to the small cohort size.

**Protection of the health of elite athletes**

Most IFs prioritized the protection of elite athlete health and had some activities in health-related areas. The “Fight against doping” was a top priority for almost all IFs. This finding was expected as inclusion in the Olympic programme requires adherence to the WADA Anti-Doping Code that mandates anti-doping programmes. Through the promotion of drug-free sport, in addition to preserving the integrity of sport, the IFs are indirectly protecting athletes from the adverse health consequences of doping. “Health of their elite athlete” and “Image as a safe sport” ranked second and third most important health-related topics for the IFs. Almost all IFs reported to have activities on “First Aid”, 85% “Injury surveillance during their championships” and “Injury prevention by regulation for equipment / venues”. More than half of the IFs stated to have “Pre-participation medical examination”. Thus, the IFs included in this survey seem to have recognized their responsibility to ensure athlete health and safety. However, only few IFs have published their results from their injury surveillance projects (e.g. IAAF, FINA, FIFA, IRB, IHF, FIS, FIVB) in the scientific literature, and only FIFA has reported about its experience with the Pre-Competition Medical Assessment. 

Despite highly prioritizing the “Health of the elite athlete”, IFs did not address all related aspects; especially “Training/competing during pregnancy”, “Mental health of athletes” and “Post-elite career management” which were addressed by very few IFs. Salmi et al. reported the prevalence of mental health issues in elite multi-sport athletes. Malcolm and Scott addressed
in a recent editorial in the British Journal of Sport Medicine suicides of elite athletes. The post-elite athletic career time period was identified as one of the most vulnerable times for the emergence of mental health issues.\textsuperscript{63}

**Protection of the health of recreational athletes**

The “Health of recreational athletes” had a relatively low importance for IFs (ranking 8 out of 10). Given the large numbers of recreational and amateur athletes globally, IFs are missing an ideal opportunity to promote health initiatives in this population. There exists a need to create policy and to support and motivate national federations and IFs to address the health and welfare of non-elite athletes. The largest sport participation in the world is football with a global participation of 265 million.\textsuperscript{65} FIFA has addressed the issue of protection of the health of the amateur and youth players by developing and implementing of exercise-based prevention programmes, \textsuperscript{66-68} and publishing information on different medical aspects for laymen (www.FIFA.com/Medical). FIFA is the only IF with a medical assessment and research centre (www.F-MARC.com) founded almost 20 years ago, and consequently has followed a risk management framework to identify, quantify, mitigate and communicate the risks of injury and ill health in football players of different, gender, age and skill levels around the world.\textsuperscript{18}

**Promotion of sport for health of the general population**

“Health of the general population” was of low importance for the IFs (ranking last of the 10 health-related topics of this survey), and few IFs had activities for the “Prevention of chronic diseases in the general population”. Furthermore, “increasing the number of recreational athletes” was of low importance for the IFs (ranking second last). Attention to the recreational athlete would not only be advantageous for the IFs in terms of popularity of the sport but also indirectly for the health of the population.

Although influencing global health through the promotion of sport is a priority of the IOC, only two IFs (FIFA and FINA) had designed programmes in response to the public health crisis of NCDs
caused by physical inactivity. These IFs are leveraging their reach and role in society to improve global health through the promotion of their sports. Their programs serve as examples of the potential role for IFs in global health promotion.

**FIFA’s Football for Health project**

‘Football for Health’ encompasses FIFA’s philosophy that football is a health-enhancing activity for all people of all ages. FIFA has initiated and supported a series of scientific studies demonstrating the value of football in the prevention of risk factors for NCDs by independent research groups. Further, FIFA developed and evaluated the “FIFA 11 for Health” programme which is a series of 11 football-based sessions aimed at encouraging PA and educating children about healthy behaviours related to communicable and NCDs. The ‘FIFA 11 for Health’ programme has been successfully implemented through the national Football Association in cooperation with the Ministries of Health, Education and Sport in currently 20 countries in Africa, Asia, Latin America, and Oceania.

**FINA’s Swim for All project**

Swimming is the only sports skill which can directly prevent death. Drowning is a significant global public health issue; the leading cause of injury for all children and the leading cause of death of all children after infancy. FINA’s ‘Swim for All’ programme focuses on drowning prevention as well as the promotion of PA in the sedentary population. The ‘IOC Sport for All’ will give promotion and support. Governmental influence to imbed learning to swim in the educational curricula world-wide is being sought in cooperation with the UNESCO. UNICEF will deliver in-depth FINA Learn to Swim programs in targeted at-risk countries. Raising awareness and encouraging governments to prevent drowning will be accomplished in collaboration with the United Nations. Although still in the initial stages of implementation and analysis of the efficacy
of this programme is pending, this initiative is another important example of the role an IF can contribute to the health in the general population.

CONCLUSION

According to the Olympic Charter, the IOC and the IFs have an obligation among others to encourage and support measures protecting the health of athletes, and to encourage and support the development of sport for all. Most IFs prioritized the health of their elite athlete as important and aimed to protect it through a variety of activities. However, increasing the number of recreational athletes and the health of their recreational athletes was of relatively low importance for them. IFs should reconsider this position as they are missing an important opportunity to contribute to increasing PA, and thus, the health of the population. Through promotion of PA in their respective sports, IFs can play a central role in the fight of the global epidemic of NCDs. FIFA and FINA projects should serve as role models.
REFERENCES


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CHAPTER 9

General Discussion
Swimming is a form of recreational activity enjoyed by many around the world. There are currently 207 member National Federations of FINA in the disciplines of swimming, diving, water polo, open water swimming, high diving and synchronized swimming. At the elite level, approximately 2500 athletes from 180 countries compete at the FINA World Championships before a cumulative global audience of 4.5 billion. FINA is the second largest International Federation at the Olympic Games with the accreditation of 1500 athletes. Participation in the aquatic sports spans the lifespan. Up to 14,000 athletes participate in the FINA Masters World Championships ranging in age between 25-97 years\(^1\). The sport of swimming is universal with both global and lifelong participation.

Along with global popularity and societal influence comes responsibility. As FINA is the custodian of the aquatic sports, it is obligated by membership in the Olympic Movement not only to protect the health of the athlete, but also to safeguard the health and well-being of the global community\(^2,3\). The purpose of this thesis is to examine the role of FINA, as an International Sports Federation, in preserving the health and well-being of the elite athlete and the global community. This thesis examines steps taken by FINA to meet the obligation to protect the health of the aquatic athlete and to promote global health. In this Chapter, the main findings are summarized and discussed. To conclude, the implications of the findings, applications for future programming and recommendations are presented.

**MAIN FINDINGS**

**Defining the problem: Injury and illness surveillance**

As per the van Mechelen model of injury prevention, the first step of injury prevention is to establish the incidence and severity of the problem (See Figure 1)\(^4\). Chapters 2 and 3 focus on this step in the injury prevention model, since little aquatic sports-related incidence and severity data is available at the elite level.
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1: Establishing the extent of the injury problem in terms of incidence and severity.

2: Establishing aetiology and mechanism of sports injuries.

3: Developing & introducing a preventive measure.

4: Assessing its effectiveness by repeating step 1 or by performing a (randomised) controlled trial.

**Figure 1:** The sequence of prevention of sports injuries.

*Athlete Health during the World Championships*

Chapters 2 and 3 describe the acute new onset injury and illness rates during the FINA World Championships in Roma 2009 and Barcelona 2013.

The 2009 study found an overall injury rate of 6.6 per 100 athletes. Females (6.8/100 athletes) were more likely to be injured than males (5.2/100 athletes). The shoulder was the most affected body part (14.6% of all injuries), followed by head (12.3%). Less than 1% (0.8 injuries/1000 registered athletes) of the registered athletes incurred an injury resulting in time-loss from sport. Overuse was the most common cause of injury (37.5%).

The 2013 study demonstrated an injury rate of 8.3/100 athletes. Water polo had the highest injury rate (15.3/100 athletes). The rate of time-loss injuries (1.4/100 athletes) in the 2013 FINA World Championships was significantly higher than in 2009. Once again, the shoulder was
identified as the most commonly injured body part (21% of all injuries) followed by the head. Two thirds of all water polo injuries were of the head/neck. The persistent finding of shoulder injuries in the aquatic sports is consistent with other studies reported in the literature 5-8.

The illness rate was significantly higher in the FINA World Championships 2013 (9.0/100 athletes) in comparison to 2009 (7.1/100 athletes). In both studies, the illness rates were higher than the injury rates demonstrating that acute illnesses in the FINA World Championships were more common than new onset injuries. While respiratory infection was the most common diagnosis in the FINA World Championships 2009, gastrointestinal illnesses were most common in 2013, followed by environmental related illnesses; jellyfish stings in open water swimming caused thirty eight percent of illnesses in open water swimmers. Few illnesses were classified as time-loss in either study.

*Out of competition health*

Chapter 3 describes a retrospective athlete survey conducted to ascertain the health of the elite aquatic athlete prior to and at the beginning of the Barcelona 2013 World Championships. The response rate was 50.2%. One-third of all athletes reported at least one physical complaint in the 4-week period leading up to the Championships, and 70% of these were still symptomatic at the commencement of the Championships. Significantly more female than male athletes reported physical complaints (36.7% versus 28.6%). The reported injury rates differed significantly amongst the disciplines with divers having the highest (55.7%) and open water swimmers the lowest (17.4%) rate. Seventy-six percent of athletes with physical complaints trained fully during this time period, while 83% reported that their performance was affected. The findings during this pre-competition window in the training period illustrate that athletes train and compete in the presence of injuries, and that their performances are affected; a phenomenon reported in the scientific literature by Bahr (2009)⁹. These injuries are not included in the traditional in-competition surveillance protocol because of the injury definition (acute new onset injury) applied.
Defining the problem: Asthma in the aquatic disciplines

To further evaluate the extent of the health issues facing elite aquatic athletes, as per Step 1 of the van Mechelen Injury Prevention Model, another study was conducted to assess a health condition common to the elite aquatic athlete: asthma/airway hyper-reactivity (AHR). This health problem also is not captured in the traditional model of injury and illness surveillance conducted during the in-competition period, which captures only new-onset health issues. As such, the study reported in Chapter 4 was conducted retrospectively on anonymized Therapeutic Use Exemption (TUE) data collected for anti-doping purposes throughout the time-period of 2004-2009. This study was a secondary analysis of non-identifiable anti-doping records, with implied and express consent ensured under the jurisdiction of Canadian law by Article 27 (Division V) of the UNESCO International Convention against Doping in Sport. As per the WADA TUE Guidelines, objective testing was required for permission to use inhaled β2 agonists during this time period. This database of athletes with objective diagnostic evidence of asthma/AHR represents a large cohort of elite athletes from various sport disciplines over an extended period of time. This database allows for comparison within the aquatic disciplines, and between the aquatic disciplines and other Olympic sports. This database also allows comparison between athletes from different geographical regions.

The predominant finding was a high prevalence of asthma/AHR in swimming compared to the other aquatic disciplines. Although there are other published studies on asthma in swimming\textsuperscript{10-12}, this particular study examined asthma/AHR in a large cohort of elite athletes using objective diagnostic criteria. Because all aquatic athletes were exposed to the pool environment of chloramines, the high prevalence of asthma/AHR in swimming relative to the other aquatic sports suggests an etiological factor other than environmental exposure, such as training intensity, type and/or duration. In comparison with other Olympic sports, the aquatic disciplines had a significantly higher prevalence of asthma than the non-endurance Olympic sports. Likewise, when comparing the prevalence of asthma/AHR in the endurance versus non-endurance aquatic disciplines, the endurance disciplines were significantly higher for all of the events during the
study period in comparison with the non-endurance aquatic discipline of diving. Findings from this study demonstrating the high prevalence of asthma/AHR in endurance versus non-endurance sports are consistent with previously published studies showing that endurance training in itself is an etiological factor in the development of asthma\textsuperscript{13-15}. Another finding was a significantly higher prevalence of asthma/AHR in North America, Oceania and Europe in comparison with South America, Asia and Africa. The reason for this geographical variation in asthma prevalence is unknown but could be due to geographical variation in prescribing practices, limitations in athlete access to knowledgeable sports physician and/or sophisticated diagnostic equipment, or related to geographical variations in chemical utilization in the pool environment.

**Addressing energy needs in the aquatic disciplines**

A review of FINA’s sport risk for energy deficiency related health issues demonstrated that four of the five aquatic disciplines are identified as being high risk. In particular, the disciplines of diving and synchronized swimming are esthetic judged sports where emphasis is placed on reaching an often unrealistic body composition\textsuperscript{16, 17}. Acknowledging that there are other sociocultural, behavioural and psychological factors involved in the development of disordered eating/eating disorders, sport pressures such as overtraining, weight cycling, and injuries as well as certain coaching behaviours are also sport risk factors\textsuperscript{18}. While there exists prevalence data on disordered eating and eating disorders in females in swimming\textsuperscript{19-22}, diving\textsuperscript{20, 22} and synchronized swimming\textsuperscript{16}, there are no prevalence data published in water polo or for the male athlete in any of the aquatic sports.

In the disciplines of swimming and open water swimming, which are both speed dependent sports, training emphasis is placed on decreasing active drag and increasing stroke efficiency. Coaching strategies, which focus on attaining an ideal body composition to maximize swimming efficiency may inadvertently result in an energy deficient state even in the absence of the psychological overlay seen in eating disorders. Well-intentioned and even justified endeavors to
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lower body fat or mass if misinformed or mismanaged may result in health and performance consequences from energy deficient states. In addition, the athlete in the middle and/or long distance events in both swimming and open water swimming may also be at risk from inadvertent over expenditure of energy from training in comparison to energy intake. Taking these factors into account, the athletes in the aquatic disciplines are vulnerable to the health and performance consequences of energy deficiency.

Chapters 5 and 6 refer to a Consensus Statement written by a panel of experienced scientists and clinicians from around the world in the field of energy deficiency in sport. These publications are an extensive review of the science resulting in an innovative change in the concept of the Female Athlete Triad. A critical analysis of the scientific literature demonstrates that the syndrome of energy deficiency affects the male athlete as well as the female athlete. In addition, there are more body systems negatively affected by energy deficiency than the Female Athlete Triad’s original construct of menstruation and bone health. Given the available evidence, it was apparent that the definition and the model of the Female Athlete Triad required clarification and modification to more accurately describe the available scientific knowledge.

In addition to this revitalization of the name and concept design, these chapters also introduce models that depict not only the health but also the performance sequelae of energy deficiency. One of the few studies investigating the effects of energy deficiency on athlete performance is the Van Heest study (2014) demonstrating a negative response to a controlled training stimulus in ovarian suppressed (energy deficient) adolescent swimmers.

The role of nutrition in promoting aquatic athlete health

Building further upon the athletes’ energy demands in the assessment of FINA’s programming for the health and well-being of the aquatic athlete, a gap in the field of sport nutrition was revealed. An effective nutrition plan is critical to athlete health and success in all aquatic sport disciplines for athletes at every stage of their development. Although a well-designed training program remains the fundamental cornerstone of successful athlete performance, the training
effect is undermined if nutrition needs are ignored. To address the identified gap, a comprehensive nutrition project was organized and implemented.

While the topic of this nutritional project is closely related to the work presented in this thesis, it was not included. Nonetheless, the overall topic and approach is interesting in regards to the overall theme of this thesis and will be briefly touched upon here. Sport nutrition experts from around the world with experience in aquatics or relevant fields were invited to participate in a FINA Nutrition Consensus Project which involved pre-meeting assignment preparation, a Consensus Meeting, a critical review of the scientific literature for assigned topics, the collaborative writing of a FINA Nutrition Consensus Statement 25 and the writing of supportive review papers in a dedicated edition of the International Journal of Sport Nutrition and Exercise Metabolism 26.

Injury and illness prevention

Although there are limited aquatic–specific studies published on injury and illness prevention through nutritional interventions, there are published data in the field that are applicable to the aquatic sports. A review of the scientific literature with respect to the role of nutrition on injury and illness prevention in the aquatic sports revealed that illness prevention can be maximized through attention to the nutritional factors that influence the immune system 27. As ascertained in Chapters 2 and 3, infectious illnesses affect the health and performance of aquatic athletes during the FINA World Championships. Specifically, energy deficiency, (the discrepancy in energy balance when dietary energy intake is less than total energy expenditure), either through voluntary restriction as seen in the aesthetic disciplines of synchronized swimming or diving, or involuntarily in the face of physically-demanding training as seen in swimming and open water swimming, can compromise athlete nutritional status, resulting in adverse effects on immunoglobulin and complement function (immunoglobulin G and M and complement C3) which are key components of the innate immune system. Manipulations of carbohydrate,
protein, fat, vitamins and micronutrient levels also can play an important role in the function of the immune system.

Likewise, while there were a limited number of studies published on the role of nutrition on injury prevention in the aquatic sports, there is evidence that low levels of Vitamin D negatively affect bone mineral density $^{29,30}$. In addition, there appears an association between low bone mineral density and an increase in stress fracture risk$^{31}$. Energy deficiency, either voluntarily or involuntarily, has been found to have a negative effect on tissue repair $^{32}$. Nutrition can play an integral role in injury recovery, in particular, with respect to modifying energy intake with the lower energy demands caused by a decrease in training volume, as well as to enhance tissue repair during injury recovery.

**Nutrition in synchronized swimming**

A review of the scientific literature addressing nutritional recommendations to improve the health and to enhance the performance of the synchronized swimmer was also included in the dedicated edition of the IJSNEM $^{26}$. Evidence-based recommendations for training with respect to the ingestion of carbohydrates, protein, fat, micronutrients and fluids were outlined in addition to a review of the literature on nutritional interventions to maximize recovery. Competition nutrition strategies were included. The scientific literature as it relates to three areas of nutritional concern unique to synchronized swimming is highlighted: i) the management of body composition, ii) the female athlete triad, and iii) eating disorders/disordered eating. Synchronized swimmers were particularly vulnerable to the health implications of these three issues, because of the aesthetic nature of this judged aquatic discipline. The prevalence data of abnormalities of the menstrual status, bone mineral density and eating disorders/disordered eating in synchronized swimming are included along with nutritional strategies to prevent and/or manage these concerns $^{28}$. 
The role of the International Federation in health promotion

In keeping with the thesis objective - to examine the role of FINA, as an International Sports Federation, in preserving the health and well-being of the athlete and the global community - a study was conducted to determine the current priorities and activities of the major International Federations (IFs) with respect to the promotion of health in their athletes and in the global population. A survey of all Olympic International Federations was conducted. In the first part of the survey the IF were asked to rate the 10 indicated topics on the basis of perceived importance. The ‘fight against doping’ had on average the highest priority, being ranked as “important” or higher by all IFs and as a “top priority” by 70%. The next two topics in order of ranked importance were “health of elite athletes” and “image as a safe sport”. In contrast, the lowest importance for the IFs was the “health of the recreational athlete”, “increasing the number of recreational athletes”, and the “health of the general population”. Thus, the IFs seem to recognize their responsibility to ensure athlete health and safety.

In the second part of the survey, IFs were asked to identify their programmes/ guidelines/research activities on 16 health-related topics. Almost all IFs reported to have activities on ‘First Aid’, 85% on ‘Injury surveillance during their championships’ and ‘Injury prevention by regulation for equipment/venues’. More than half of the IFs stated to have ‘Pre-participation medical examination’. However, only a few IFs have published their results from their injury surveillance projects in the scientific literature, and only one IF (FIFA) had reported about its experience with the Pre-Competition Medical Assessment. Despite highly prioritizing the “Health of the elite athlete”, IFs did not address all related health aspects; especially “Training/competing during pregnancy”, “Mental health of athletes” and “Post-elite career management”. Significant differences between team and individual sports IFs (FINA excluded) were found for “injury prevention by exercise-based programmes” (p<.05, all team sports vs. 50% of individual sports), “injury prevention by Fair Play” (p<.05, 6 of 7 teams sports vs. 34.6% of individual sports), “Pre-participation medical examination” (p<.05, all team sports vs. 42.3% of individual sports).

With respect to attention to the health of the global population, “Health of the general
population” was of low importance for the IFs (ranking last of the 10 health-related topics of this survey), and few IFs had activities for the “Prevention of chronic diseases in the general population”. Furthermore, “increasing the number of recreational athletes” was of low importance for the IFs (ranking second last). Attention to the recreational athlete would not only be advantageous for the IFs in terms of popularity of the sport, but also indirectly for the health of the population. While eight (23.5%) IFs reported having activities related to “Prevention of chronic diseases in the general population”, only 2 IFs – FIFA and FINA had programs to address the public health crisis of the alarming rise in morbidity and mortality from NCD.

**METHODOLOGICAL ISSUES**

Due the study designs of the various components of this thesis, some methodological issues are evident that pose limitations on the interpretation of the results.

*Acute new-onset injury and illness surveillance in-competition*

In particular, in the prospective acute new-onset injury and illness surveillance studies at the FINA World Championships in Chapters 2 and 3, the coverage of athletes was 67.3% (2009) and 70.7% (2013), respectively. Athlete coverage at the Olympic Games is much higher at 88% (2008), 94.2% (2010), 96% (2012) illustrating that improved compliance is required to more accurately assess injury and illness incidence. In the Olympic and FINA experience, the response rate improved over time, which may reflect team physician familiarity with the study protocol. The incidence of all and of time-loss injuries during the 2013 study was significantly higher than in 2009. Although this significant difference could be due to increasingly tougher competition or to a busier competition calendar with a consequent decreased recovery period and a subsequent increased injury risk, it could also be attributed to improved familiarity of the team physicians.
with the injury surveillance system. Ongoing injury surveillance is required to decrease this reporting bias.

Apparent also during the analysis of the FINA World Championship injury and illness data is that the IOC surveillance system\(^ {47} \) that was utilized has limitations in its application to the aquatic sports. For instance, this protocol does not provide guidance with respect to athlete exposure for swimming relays, synchronized swimming teams or synchronized diving. In addition, the reporting forms are not designed to be aquatic specific. For example, there are limitations with reporting the location of injury (body part). As so many injuries in water polo are to the head, further delineation is required to differentiate between injuries to the eye, ear, face, dentition or brain (concussion). Likewise, when analyzing the cause of injury, the IOC surveillance system does not clearly define the nature of overuse injuries that are reported to be as high as 37.5%. Finally, an important methodological challenge in the IOC surveillance system is that it captures only acute new-onset injuries during the in-competition time period. Evident from the retrospective survey described in Chapter 3, many injuries that are not acute new-onset, and that occur in the out-of-competition time period are not captured in this protocol.

*Retrospective survey on injuries 4 weeks prior to the FINA World Championships*

There are also methodological challenges with the retrospective survey on athlete injuries in the 4-week period leading into World Championships reported in Chapter 3. The response rate of this survey was only 50.2%, which demonstrates the potential for self-selection bias. As with all voluntary surveys, there is a self-selection bias. In addition, there are limitations to the accuracy of the retrospective survey with a potential for underestimation of injuries related to a potential recall bias\(^ {48, 49} \). An inherent methodological challenge with the retrospective study design in this survey is the underestimation of actual injury rates in the elite aquatic athletes. The athletes with more severe injuries, who were subsequently unable to qualify for the FINA World Championships, were not captured in this study. A methodological strength of this survey design was the recording of athlete symptoms rather than diagnoses, which allowed for greater capture
of performance affecting physical complaints by bypassing potential reporting bias of third party
recorders who may interpret differently a recordable problem. This approach provided a more
accurate interpretation of the effect that physical complaints may have on athletic performance
50.

Retrospective analysis of therapeutic use exemptions for asthma/ AHR

Utilizing a retrospective design of TUE analysis in a finite period of time does not allow for the
acquisition of information on the natural history of the disease. In addition, analyzing TUE data
to diagnose asthma/AHR has itself inherent limitations and potential bias. The acquisition of a
TUE requires the athlete to have access to a sports physician who is knowledgeable of the WADA
TUE program as well as facilities to perform the objective diagnostic testing. As such, the
prevalence may be underestimated. In contrast however, there is published data to suggest that
TUE data may actually overestimate the diagnosis of asthma/AHR identifying athletes who are
asymptomatic 51.

Energy issues in the aquatic sports

Chapters 5 and 6 are Consensus Statement documents that represent an extensive review of
the scientific literature as well as the expertise and experience of scientific and clinical experts
from around the world in the field of energy deficiency in elite sport. While review papers
provide a helpful analysis of the science of a particular topic, there are methodological
limitations in the design of these publications. These papers are not systematic reviews that
apply a greater degree of rigor in the inclusion and exclusion criteria. While these consensus
documents introduce an innovative change in the conceptualization of energy deficiency in elite
sport, they also identify gaps in the current science base. It is evident that there is need for
further research on RED-S in the aquatic sports to ascertain the prevalence in both female and
male athletes, the extent of health and performance sequelae of energy deficiency, and the
efficacy of the RED-S Clinical Assessment Tool (RED-S CAT).
The role of the International Federation in health promotion

As with the retrospective survey outlined in Chapter 3, the methodology in the study presented in Chapter 8 has the potential for self-report bias. In addition, there is no validation of the presence or quality of the reported activities/programmes. Given that the cohort was intentionally limited to Olympic IFs, there is limited application beyond this population. Due to the small cohort size of team sports (n=6) vs. individual sports (n=16) and winter sports (n=5) vs. summer sports (n=27), differences should be interpreted with caution.

IMPLICATIONS AND APPLICATIONS

According to the FINA quadrennial report (2013)52, Aquatics is a sport based on:

- Safety: a sport that saves lives
- Citizenship: a sport based on values
- Environment: a sport that preserves nature

These FINA values of athlete safety and global citizenship are congruous with the objectives of thesis and help to drive the rationale for the studies. As the purpose of this thesis is to examine the role of FINA in preserving the health and well-being of the athlete and the global community, findings from the various projects in this thesis have direct implications and applications for FINA.

In competition athlete health surveillance

With respect to the promotion of athlete health and safety, the results from the studies on in-competition injury and illness surveillance illustrate opportunities for future programming to improve athlete health and performance. In particular, the methodological limitations as
Chapter 9: General Discussion

outlined above demonstrate the need for FINA to better refine the in-competition injury and illness surveillance protocols to:

- Define more accurately athlete exposures
- Better clarify aquatic-specific injury location and causation
- Improve accuracy of reporting and athlete coverage

The findings from the two in-competition studies conducted during the FINA World Championships identify areas of health risk, which warrant attention and mitigation. As per the van Mechelen model \(^4\), Step 2 involves further study of the identified problem from Step 1 to establish the aetiology and mechanism of injury through the identification of both intrinsic and extrinsic risk factors \(^5\). The problems identified in the FINA Injury and Illness surveillance during the World Championships that require further investigation and prevention interventions presented in this thesis include:

1) Shoulder injuries
2) Head injuries
3) Overuse injuries
4) Water polo safety
5) Safety of the open water swimming environment

Once Step 2 has been completed, targeted prevention programs and recommendations can be implemented in Step 3 and re-studied for efficacy in Step 4 \(^4\).
The role of International Sports Federations in safeguarding the health and well-being of athletes

Lessons learned from FINA’s activities

Out of competition athlete health surveillance

The reported causation of 37.5% of all injuries during the in-competition injury surveillance was overuse injuries. The retrospective athlete survey on physical complaints prior to the World Championships discovered that 36.7% of all respondents reported physical symptoms during the study period, and 83% of these were felt to have affected performance. These findings clearly demonstrate that the in-competition surveillance of new-onset acute injuries is not capturing the entire picture of athlete health. To better understand the health of the elite aquatic athlete, FINA should also prospectively monitor athlete health during the training period.

A prospective health surveillance system would also better capture information on the respiratory health of the aquatic athlete. Given the high prevalence of asthma/AHR found in the Therapeutic Use Exemption study presented in Chapter 4, there is a need to better understand the natural history of asthma in swimming: does the endurance training regimen of swimming cause asthma/AHR? What are the exacerbating factors of asthma/AHR? Does the aquatic athlete see reversion of their lung function to normal post retirement?

Knowledge translation

It is well known that the utility of scientific knowledge is limited at a practical level and that implementing effective interventions in the real life sport setting are challenging. To be most effective in impacting athlete/coach behavioural change through the implementation of prevention models, FINA should adopt ‘knowledge translation’ principles described in the scientific literature. In particular, to maximize the success of interventions stemming from scientific evidence, a top down approach to the program development following the five-step Knowledge Translation Scheme is recommended.
Figure 2. Five-step Knowledge Transfer Scheme\textsuperscript{60}.

Step 5 dictates that the product package be evaluated for establishment of efficacy. An evaluation protocol, known as the RE-AIM Framework, was originally designed for public health promotion interventions but can be adopted for products delivered by sport governing bodies. The RE-AIM Framework assesses product Reach, Effectiveness, Adoption, Implementation and Maintenance. This evaluation model can be utilized to evaluate knowledge and behavioural change secondary to the introduction of the FINA prevention interventions\textsuperscript{61}.

The Relative Energy Deficiency in Sport Clinical Assessment Tool (RED-S CAT) is introduced in Chapter 7. This tool is designed to aid in the clinical management of the athlete with RED-S. It provides a framework for the team physician for both the screening of athletes at high risk for energy deficiency as well as a return to play model for those athletes already diagnosed with RED-S. The RED-S CAT is based on the scientific evidence reviewed in Chapters 6 and 7. The RED-S CAT therefore represents a “top down” approach to knowledge translation as per the Verhagen
model. The task now for FINA is to educate the athlete health support teams in the four ‘at risk’ aquatic disciplines about RED-S and the RED-S CAT utilizing the 5-step Knowledge Transfer Scheme and the RE-AIM Framework.

The nutrition recommendations on the role of nutrition in injury and illness prevention, and in synchronized swimming provide for FINA a summarized evidence base to support aquatic athlete health protection. These recommendations, in addition to all of the related FINA Nutrition publications from the Consensus project published in the dedicated edition of the International Journal of Sport Nutrition and Exercise Metabolism, serve as a scientific guide for sport science teams that support the aquatic sports. The challenge now for FINA is to take the next step to translate the knowledge in these reviews to provide practical intervention tools for athletes, coaches and the athlete entourage also utilizing models described above.

FINA’s role in health promotion

Given that 70% of the world’s surface is covered in water and that swimming is a teachable skill, it is disturbing that death by drowning has become a significant public health problem and the leading cause of death for children after infancy. Up to 200,000 children die per year from drowning with peaks noted in children under the age of 5 years. The country with the highest drowning rate is Bangladesh (28.6/100,000 child years). Swimming lessons have been shown to decrease drowning risks in developed countries and in low-middle income countries. At the same time, there is another public health epidemic of global proportion facing modern society: the rise in prevalence of non-communicable diseases (NCD). Insufficient physical activity has been classified by the World Health Organization as the fourth leading risk factor for global mortality from NCDs following hypertension, tobacco use and high blood glucose. Insufficient physical activity is responsible for 3.2 million or 5.5% of all deaths.

FINA, as a member of the Olympic Movement, shares with other International Federations the
responsibility to promote physical activity through sport:

*Everyone involved in the Olympic Movement must become more aware of the fundamental importance of Physical Activity and sport for a healthy lifestyle, not least in the growing battle against obesity, and must reach out to parents and schools as part of a strategy to counter the rising inactivity of young people* 69.

Amongst all International Sport Federations, FINA is unique in that it is the only sport where learning the sport skill can actually save a life through drowning prevention in addition to realizing the health benefits of physical activity. The survey results presented in Chapter 7 illustrate the large void at the International Federation level in addressing global health through the promotion of physical activity. FINA has the opportunity to lead by example through the implementation of a global health promotion project in collaboration and cooperation with UNESCO, unicef, governments and other not-for-profit global organizations. The IOC has outlined principles and recommendations for sport organizations in response to the global health crisis of rising NCDs 70.

*Sport organisations have a role to play in the realisation of the global recommendations for young people to accumulate at least 60 min per day of moderate-to-vigorous intensity. Physical activity in addition to the activity they accrue as part of everyday living.*

• *identify and lower the barriers to participation in sport;*
• *collaborate with youth, parents, school personnel and community programmes to design and deliver sports programmes that attract and retain young people;*
• *foster collaboration with international, regional and national PA promotion networks;*
• *evaluate and improve the quality and delivery of sport programmes for young developing athletes.*

Given this unique role, FINA’s attention to the design, delivery, implementation and evaluation of the FINA Learn to Swim program is necessary to fulfill FINA’s obligation and moral responsibility as a global citizen in modern-day society. While outside the normal realm of the business of elite sport that is familiar to the International Federation, FINA should broaden its
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scope to provide solutions to the serious health risks and societal costs of physical inactivity.²

Despite having rated ‘health of elite athletes’ and ‘image as a safe sport’ as a high priority by International Federations, a gap in athlete health programming was identified in Chapter 7. The three lowest ranked priorities for the International Federations were “Training/competing during pregnancy”, “Mental health of athletes” and “Post-elite career management”. Evaluation of FINA’s athlete health promotion program reveals that FINA does not have any programs in place to address these three topic areas. On average, the lowest importance for the IFs was the ‘health of the general population’. As with the global health initiative, FINA has an obligation to address these areas of athlete health risk.

CONCLUSIONS

As a member of the Olympic Movement, FINA is governed by the Olympic Charter to protect the health of its participating athletes and to promote physical active in the global community. This thesis describes the many steps that FINA has taken to preserve the health and well-being of the elite aquatic athlete and the global community. Through its various programs, FINA is addressing in-competition injury and illness risk through the implementation of a surveillance protocol. Out-of-competition or training health surveillance of the elite aquatic athlete is not as well developed. Risk mitigation intervention programs have not been designed or implemented. Although in the development stage, FINA has a global health program to address the alarming drowning rates and to promote physical activity to reduce the risk of morbidity and mortality from NCD.

Resulting from the evidence from the studies presented in this thesis, several concluding recommendations for FINA can be drawn to facilitate and focus its efforts to improve athlete and global health and well-being.

It is recommended that FINA:

• Critically analyze and enhance the in-competition injury and illness surveillance program;
• Implement an out-of-competition injury and illness surveillance program;

• Develop and implement intervention programs addressing areas of elite aquatic athlete health risks;

• Address the high prevalence of asthma/ AHR through further evaluation and implementation of awareness and management protocols;

• Ascertain the prevalence of RED-S in the aquatic disciplines and implement / evaluate the efficacy of the RED-S CAT;

• Develop and evaluate efficacy of interventions to promote nutrition in the elite aquatic disciplines;

• Design, implement and evaluate a global health strategy to minimize deaths by drowning and to promote swimming for all to reduce the rise in non-communicable diseases caused by physical inactivity.
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Chapter 9: General Discussion


The role of International Sports Federations in safeguarding the health and well-being of athletes

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Summary
The sport of swimming is universal with global participation at all ages from the recreational level to elite level. FINA, the international governing body of the aquatic disciplines of swimming, diving, water polo, open water swimming, high diving and synchronized swimming, has 207 member National Federations. Along with global popularity comes social responsibility. FINA, as the custodian of the aquatic sports, is obligated by membership in the Olympic Movement not only to protect the health of the athlete, but also to safeguard the health and well-being of the global community.

The purpose of this thesis is to examine the role of FINA, as an International Sports Federation, in preserving the health and well-being of the elite athlete and the global community. This thesis outlines the steps taken by FINA to meet the obligation to protect the health of the aquatic athlete and to promote global health.

**DEFINING THE PROBLEM**

*Injuries and illnesses in the aquatic sports*

Two studies in this thesis describe the rates of acute new onset injury and illness rates during the FINA World Championships in Roma 2009 and Barcelona 2013. Results show that females were more likely to be injured than males, and that the shoulder was the most affected body part followed by the head. Severe injuries, as defined by time-loss from sport, were uncommon. Overuse injuries were the most common cause of injury. Two-thirds of all injuries in water polo were of the head and neck.

Illness rates during the FINA World Championships were higher than injury rates. Respiratory illnesses were the most common illness in 2009 and gastrointestinal illnesses in 2013. Other causes of illness included environmental related illnesses and jelly fish stings in open water swimming. The reported illnesses were also not severe.
Summary

To more clearly define the state of the health of the aquatic athlete, a retrospective survey was conducted in 2013. This survey assessed the presence of physical complaints in the 4 week period leading up to the FINA World Championships and showed that one-third of all athletes reported at least one physical complaint in the 4-week period leading up to the Championships, and 70% of these were still symptomatic at the commencement of the Championships. Significantly more female than male athletes reported physical complaints. The reported injury rates differed significantly amongst the disciplines with divers having the highest and open water swimmers the lowest rate. Three quarters of athletes with physical complaints trained fully during this time period, while 83% reported that their performance was affected. The findings during this pre-competition window in the training period illustrate that athletes train and compete in the presence of injuries, and that their performances were affected.

A final study on the health of the athlete during the training period was conducted to determine the prevalence of asthma in the aquatic disciplines. The predominant finding was a high prevalence of asthma in swimming compared to the other aquatic disciplines. Because all aquatic athletes were exposed to the chemicals in the pool environment, the high prevalence of asthma in swimming relative to the other aquatic sports suggests a causative factor other than environmental chemical exposure, such as training intensity, type and/or duration. In comparison with other Olympic sports, the aquatic disciplines had a significantly higher prevalence of asthma than the non-endurance Olympic sports. Likewise, when comparing the prevalence of asthma, the endurance aquatic disciplines were significantly higher in comparison with the non-endurance aquatic discipline of diving.

Addressing energy needs in the aquatic disciplines

The syndrome of Relative Energy Deficiency in Sport (RED-S) refers to impaired physiological functioning caused by relative energy deficiency, and includes but is not limited to impairments of many body systems including menstrual function, bone health, immunity, protein synthesis, metabolic rate and cardiovascular health. The cause of the RED-S is the scenario termed ‘low energy availability’, where an individual’s dietary energy intake is insufficient to support the
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energy expenditure required for health, function and daily living, once the costs of exercise and sporting activities are taken into account.

A review of FINA’s risk for relative energy deficiency related health issues demonstrated that four of the five aquatic disciplines are identified as being high risk. In particular, the disciplines of diving and synchronized swimming are esthetic judged sports where emphasis is placed on reaching an often unrealistic body composition. In the disciplines of swimming and open water swimming, which are both speed dependent sports, training emphasis is placed on decreasing active drag and increasing stroke efficiency. In addition, the athlete in the middle and/or long distance events in both swimming and open water swimming may also be at risk from inadvertent over expenditure of energy from training in comparison to energy intake. Taking these factors into account, the athletes in the aquatic disciplines are vulnerable to the health and performance consequences of relative energy deficiency. The scientific review papers in this thesis define the syndrome of RED-S and introduce conceptual models as well as screening and return-to-play models.

Role of international federation in health promotion

Another study was conducted to examine the role of FINA, as an International Sports Federation, in preserving the health and well-being of the athlete and the global community. This study surveyed all Olympic International Federations to ascertain the current priorities and activities of the major International Federations (IFs) with respect to the promotion of health in their athletes and in the global population. In the first part of the survey, the IFs were asked to rate 10 health related topics on the basis of their perceived importance. The ‘fight against doping’ had on average the highest priority. The lowest importance for the IFs was the “health of the recreational athlete”, “increasing the number of recreational athletes”, and the “health of the general population”. Thus, the IFs seem to recognize their responsibility to ensure athlete health and safety.
In the second part of the survey, IFs were asked to identify their programmes/ guidelines/ research activities on 16 health-related topics. Despite highly prioritizing the “Health of the elite athlete”, IFs did not address all related health aspects; especially “Training/competing during pregnancy”, “Mental health of athletes” and “Post-elite career management”. With respect to attention to the health of the global population, “Health of the general population” was of low importance for the IFs (ranking last of the 10 health-related topics of this survey), and few IFs had activities for the “Prevention of chronic diseases in the general population”. Furthermore, “increasing the number of recreational athletes” was of low importance for the IFs (ranking second last). While eight IFs reported having activities related to “Prevention of chronic diseases in the general population”, only 2 IFs – FIFA and FINA had programs to address the public health crisis of the alarming rise in illness and death from non-communicable diseases.

**IMPLICATIONS AND APPLICATIONS**

According to the FINA quadrennial report (2013), Aquatics is a sport based on:

- Safety: a sport that saves lives
- Citizenship: a sport based on values
- Environment: a sport that preserves nature

The FINA values of athlete safety and global citizenship are congruous with the objectives of thesis and help to drive the rationale for the studies. As the purpose of this thesis is to examine the role of FINA in preserving the health and well-being of the athlete and the global community, findings from the various projects in this thesis have direct implications and applications for FINA.

**In- and out-of-competition injury and illness**

With respect to the promotion of athlete health and safety, the results from the studies on in-competition injury and illness surveillance illustrate opportunities for future programming to improve athlete health and performance. The problems identified in the FINA Injury and Illness
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surveillance during the World Championships that require further investigation and prevention interventions presented in this thesis include:

- Shoulder injuries
- Head injuries
- Overuse injuries
- Water polo safety
- Safety of the open water swimming environment

The findings from the studies on injuries during and prior to the FINA World Championships clearly demonstrate that the current in-competition surveillance is not capturing the entire picture of athlete health. To better understand the health of the elite aquatic athlete, FINA should therefore also monitor athlete health during the training period. Given the high prevalence of asthma found in aquatic disciplines, asthma should also be monitored during this time period. There is also a need for further studies to better understand the nature of asthma in swimming.

Knowledge translation

Resulting from the scientific knowledge identified in the studies in this thesis, the task for FINA is to now translate this information into effective action to promote and protect the health of the aquatic athlete. For example, for the four ‘at risk’ aquatic disciplines for RED-S, FINA should develop an educational program for the athlete health support teams to raise awareness of the syndrome and to introduce the clinical assessment tools utilizing various knowledge translation scheme. Another example is the translation of the knowledge on nutrition in the aquatic sports into coach and athlete-focused educational tools.

FINA’s role in health promotion

Given that 70% of the world’s surface is covered in water and that swimming is a teachable skill, it is disturbing that death by drowning has become a significant public health problem and the
leading cause of death for children after infancy. Swimming lessons have been shown to decrease drowning risks. At the same time, there is another public health epidemic of global proportion facing modern society: the rise in prevalence of non-communicable diseases. Insufficient physical activity has been classified by the World Health Organization as the fourth leading risk factor for global mortality from non-communicable diseases following hypertension, tobacco use and high blood glucose. Insufficient physical activity is responsible for 3.2 million or 5.5% of all deaths.

FINA, as a member of the Olympic Movement, shares with other International Federations the responsibility to promote physical activity through sport. Amongst all International Sport Federations, FINA is unique in that it is the only sport where learning the sport skill can actually save a life through drowning prevention in addition to realizing the health benefits of physical activity. FINA has the opportunity to lead by example through the implementation of a global health promotion project in collaboration and cooperation with UNESCO, unicef, governments and other not-for-profit global organizations. Given this unique role, FINA’s attention to the design, delivery, implementation and evaluation of the FINA Learn to Swim program is necessary to fulfill FINA’s obligation and moral responsibility as a global citizen in modern-day society. While outside the normal realm of the business of elite sport that is familiar to the International Federation, FINA should broaden its scope to provide solutions to the serious health risks and societal costs of physical inactivity.

CONCLUSIONS

Resulting from the evidence from the studies presented in this thesis, the recommendations for FINA can facilitate and focus its efforts to improve athlete and global health and well-being.
Samenvatting
Zwemmen is een universele sport met wereldwijde deelname van alle leeftijden, van recreatief niveau tot elite. FINA, het internationale bestuursorgaan van de aquatische disciplines zwemmen, duiken, waterpolo, open water zwemmen, hoge duiken en synchroon zwemmen, heeft 207 Nationale Federaties als lid. Samen met wereldwijde populariteit komt ook maatschappelijke verantwoordelijkheid. FINA, als bewaarder van de watersport, is verplicht door het lidmaatschap van de Olympische Beweging, niet alleen om de gezondheid van de sporter te beschermen, maar ook om de gezondheid en het welzijn van de wereldwijde gemeenschap te beschermen.

Het doel van dit proefschrift is om de rol van FINA, als een Internationale Sport Federatie, in het behoud van de gezondheid en het welzijn van de topsporter en de wereldwijde gemeenschap te onderzoeken. Dit proefschrift beschrijft de stappen die FINA aan de verplichting ter bescherming van de gezondheid van de atleet te voldoen en om de wereldwijde gezondheid te bevorderen.

DEFINITIE VAN HET PROBLEEM

**Blessures en ziekten in de watersport**

Twee studies in dit proefschrift beschrijven het aantal acute en (nieuwe) letsels en ziekten tijdens de FINA WK’s in Rome 2009 en Barcelona 2013. De resultaten tonen aan dat vrouwen meer kans hebben op letsel dan dan mannen, en dat de schouder het meest getroffen lichaamsdeel is gevolgd door het hoofd. Ernstige verwondingen, zoals gedefinieerd door de tijdverlies van sport, waren ongewoon. Overbelasting was de meest voorkomende oorzaak van letsel. Tweederde van alle letsels in waterpolo zijn aan het hoofd en de nek.

Om de gezondheidsstoestand van de aquatische atleet duidelijker te definiëren, werd een retrospectief onderzoek uitgevoerd in 2013. Dit onderzoek onderzocht de aanwezigheid van lichamelijke klachten in de periode van 4 weken voorafgaand aan de FINA World Championships en toonde aan dat 1/3 van alle atleten ten minste één fysieke klacht had in deze periode in de aanloop naar het kampioenschap. Bovendien waren 70% van deze klachten nog symptomatisch bij de aanvang van de kampioenschappen. Significant meer vrouwelijke dan mannelijke atleten meldden lichamelijke klachten. De gemelde letsel aantallen verschilden aanzienlijk tussen de disciplines, met duikers het hoogste en open water zwemmers het laagste aantal. Driekwart van atleten met lichamelijke klachten hebben volledig getraind in deze periode, terwijl 83% meldde dat hun prestaties werden beïnvloed. De bevindingen in dit venster van training in aanloop naar competitie illustreerden dat atleten trainen en wedstrijden zwemmen in de aanwezigheid van lestels, en dat hun prestaties hierdoor wordt beïnvloed.

Een laatste onderzoek naar de gezondheid van de atleet gedurende de trainingsperiode werd uitgevoerd om de prevalentie van astma te bepalen in de aquatische disciplines. De belangrijkste bevinding was een hogere prevalentie van astma bij zwemmen in vergelijking met de andere aquatische disciplines. Omdat alle atleten in hun training zijn blootgesteld aan de chemicaliën in het zwembad, suggereert de hoge prevalentie van astma bij het zwemmen ten opzichte van de andere watersporten een andere oorzaak dan de milieu blootstelling aan chemische stoffen. Te denken valt aan de trainingsintensiteit, het type inspanning en / of de duur als oorzakelijke factoren. In vergelijking met andere Olympische sporten, hebben de aquatische disciplines een significant hogere prevalentie van astma dan de niet-endurance Olympische sporten.

**Het aanpakken van de energiebehoefte in de aquatische disciplines**

Het syndroom van relatieve energie deficiëntie in sport (RED-S) verwijst naar een vermindering van fysiologische processen veroorzaakt door relatieve energiedeficiëntie en omvat, maar is niet beperkt tot, stoornissen van vele orgaansystemen waaronder de menstruele functie, de bot gezondheid, het immuun systeem, de eiwitsynthese, het metabolisme en de cardiovasculaire gezondheid. De oorzaak van de RED-S is het zogenaamde 'low energy availability', waarbij
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energieopname door voeding bij een individu onvoldoende is voor het energieverbruik nodig voor de gezondheid, functie en dagelijks leven.

Vier van de vijf aquatische disciplines zijn geïdentificeerd als hoog risico voor energie deficiëntie. Met name de disciplines duiken en synchroon zwemmen zijn esthetische beoordeelde sporten waarbij de nadruk op het bereiken van een vaak onrealistische lichaamssamenstelling wordt geplaatst. In de disciplines van het zwemmen en open water zwemmen, die beiden snelheidsafhankelijke sporten zijn, wordt bij de training de nadruk gelegd op het verminderen van het actieve slepen en het verhogen van de slag efficiëntie. Bovendien kan de midden of lange afstand zwemmer ook het risico lopen dat tijdens training het energieverbruik hoger is dan de energie-inname. Rekening houdend met deze factoren zijn de atleten in de aquatisch disciplines kwetsbaar voor de gevolgen van relatieve energie-deficiëntie. De wetenschappelijke overzichtsartikelen in dit proefschrift definiëren het syndroom van RED-S en dragen conceptuele modellen aan, evenals screening en return-to-play-modellen.

Rol van de internationale federatie in gezondheidsbevordering

Een andere studie werd uitgevoerd om de rol van de FINA, als een Internationale Sport Federatie, in het behoud van de gezondheid en het welzijn van de sporter en de wereldwijde gemeenschap te onderzoeken. Deze studie evaluateerde van de belangrijkste Olympische Internationale Federaties (IF) de huidige prioriteiten en de ondernomen activiteiten met betrekking tot de bevordering van de gezondheid in hun atleten en in de mondiale bevolking. In het eerste gedeelte van het onderzoek zijn de federaties gevraagd om 10 gezondheidgerelateerde onderwerpen te ordenen naar belang. De ' strijd tegen doping' had gemiddeld de hoogste prioriteit. De laagste belangen voor de federaties waren de "gezondheid van de recreatieve atleet", "het verhogen van het aantal recreatieve sporters", en de "gezondheid van de bevolking". De federaties lijken in het algemeen hun verantwoordelijkheid te erkennen ten aanzien van het garanderen van de gezondheid en de veiligheid van atleten.
Samenvatting

In het tweede deel van het onderzoek werden federaties gevraagd om hun programma’s, richtlijnen en onderzoeksactiviteiten op 16 gezondheidsgerelateerde onderwerpen te identificeren. Ondanks dat de "gezondheid van de topsporter” hoog werd geprioriteerd hadden de federaties geen programma’s voor aanverwante gezondheidsaspecten; vooral "training / competitie tijdens de zwangerschap", "geestelijke gezondheid van de atleten" en "post-elite carrière management” waren onderwerpen zonder activiteit. De gezondheid van de wereldbevolking was van laag belang voor de federaties; laagste ranking van de 10 gezondheidsgerelateerde onderwerpen. Enkele federaties hadden activiteiten voor de “preventie van chronische ziekten in de algemene populatie". Bovendien was "het verhogen van het aantal recreatieve sporters" van laag belang voor de federaties (ranking voorlaatste). Terwijl acht federaties meldten dat er activiteiten waren die verband hielden met "preventie van chronische ziekten in de algemene bevolking", zijn er slechts 2 federaties (FIFA en FINA) die werkelijk programma’s hadden om de alarmerende stijging van de leefstijl gerelateerde aandoeningen in de bevolking aan te pakken.

Implicaties en TOEPASSINGEN

Volgens het vierjaarlijkse FINA rapport (2013), is aquatics een sport op basis van:

Veiligheid: een sport die levens redt

Burgerschap: een sport op basis van waarden

Milieu: een sport die de natuur behoudt

De FINA waarden van de veiligheid van de sporter en de bevolking zijn congruent met de doelstellingen van dit proefschrift. Aangezien het doel van dit proefschrift is om de rol van FINA in het behoud van de gezondheid en het welzijn van de sporter en de internationale gemeenschap te onderzoeken, hebben de bevindingen van de beschreven projecten in dit proefschrift directe implicaties en toepassingen voor FINA.
**In- en out-of-competition blessure en ziekte**

Met betrekking tot de bevordering van de gezondheid en veiligheid van de atleet, illustreren de resultaten van de studies naar letsels en ziekten mogelijkheden voor toekomstige programmering om de gezondheid en de prestaties van atleten te verbeteren. De uitkomsten van de FINA letsel en ziekte surveillance tijdens het WK, tonen aan dat verder onderzoek enpreventieve interventies nodig zijn voor:

- Schouderletsels
- Hoofdletsels
- Overbelastingsletsels
- Waterpolo veiligheid
- Veiligheid van het open water zwemmen

De resultaten van de studies over letsels gedurende en vóór de FINA WK tonen duidelijk aan dat de huidige in-competition surveillance niet in staat is om een geheel beeld van de gezondheid van de atleet te geven. Om beter inzicht in de gezondheid van de elite aquatische atleet te krijgen, moet FINA dus ook de gezondheid monitoren tijdens de trainingsperiode. Gezien de hoge prevalentie van astma gevonden in aquatische disciplines, moet astma ook worden gecontroleerd tijdens deze periode. Er bestaat ook behoefte aan studies naar beter inzicht in de aard van astma bij het zwemmen.

**Kennis vertaling**

De taak voor FINA is om de wetenschappelijke kennis die in de studies in dit proefschrift is beschreven te vertalen naar effectieve actie ter bevordering en bescherming van de gezondheid van de aquatische atleet. Bijvoorbeeld, voor de vier aquatische disciplines met een hoog risico voor RED-S, moet FINA een educatief programma ontwikkelen voor de atleet en de medische staf.
om de bewustwording van het syndroom te verhogen en om klinische evaluatie-instrumenten te introduceren. Een ander voorbeeld is de vertaling van de kennis over voeding naar educatieve middelen gericht op de coach en atleet.

**De rol van FINA in gezondheidsbevordering**

Gezien het feit dat 70% van de oppervlakte van de wereld is bedekt met water en dat zwemmen een leergierig vaardigheid is, is het is verontrustend dat de dood door verdrinken de belangrijkste doodsoorzaak voor kinderen is. Het is aangetoond dat zwemlessen het risico op verdrinken verminderen. Tegelijkertijd, heeft de moderne maatschappij te maken met een andere volksgezondheid epidemie van globale proporties; de stijging van de prevalentie van niet-overdraagbare ziekten. Onvoldoende fysieke activiteit is ingedeeld door de World Health Organization als de vierde belangrijkste risicofactor voor de wereldwijde sterfte van niet-overdraagbare ziekten na hypertensie, het gebruik van tabak en een hoge bloedsuikerspiegel. Onvoldoende fysieke activiteit is verantwoordelijk voor 3,2 miljoen of 5,5% van alle stefgevallen.

FINA, als lid van de Olympische Beweging, deelt met andere internationale federaties de verantwoordelijkheid om fysieke activiteit te bevorderen door middel van sport. Onder alle internationale sportfederaties, is FINA uniek omdat zwemmen de enige sport is waarbij het leren van de sport daadwerkelijk levens kan redden door verdrinken te voorkomen, naast het realiseren van de voordelen voor de gezondheid door lichamelijke activiteit. FINA heeft de mogelijkheid om het goede voorbeeld te geven door de invoering van een wereldwijd project naar de bevordering van gezondheid via een samenwerking met UNESCO, UNICEF, overheden en andere not-for-profit organisaties. Gezien deze unieke rol, is FINA's aandacht voor het ontwerp, de levering, de implementatie en evaluatie van het FINA ‘Learn to Swim’ programma noodzakelijk om de verplichtingen en morele verantwoordelijkheden van FINA te vervullen. Ondanks dat dit buiten de normale sfeer van het bedrijf van de topsport ligt, een rol waarmee een Internationale Federatie vertrouwd is, moet FINA haar scope uitbreiden om bij te dragen aan oplossingen voor de ernstige gezondheidsrisico's en maatschappelijke kosten van lichamelijke inactiviteit.
**Conclusies**

De aanbevelingen voor FINA die voortvloeien uit de resultaten gepresenteerd in de hoofdstukken van dit proefschrift, kunnen positief bijdragen aan de inspanningen van FINA om de gezondheid en het welzijn van de (elite) sporter en de wereldbevolking te verbeteren.
Thanks

A special thank you to the reading committee:

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