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The International Olympic Committee (IOC) Consensus Statement on periodic health evaluation of elite athletes March 2009

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The Olympic Games is the largest sport event in the world. In Beijing, 10 500 athletes competed, selected from a large group of elite athletes in 204 countries. Sports participation on the elite level, aside from winning medals, fame and other rewards, is also important from a health perspective. There is no longer any doubt that regular physical activity

reduces the risk of premature mortality in general, and of coronary heart disease, hypertension, colon cancer, obesity and diabetes mellitus in particular. The question is whether the health benefits of sports participation outweigh the risk of injury and long-term disability, especially in high-level athletes. Sarna *et al*¹ have studied the incidence of chronic disease and life expectancy of former male world-class athletes from Finland in endurance sports, power sports and team sports. The overall life expectancy was longer in the high-level athlete compared with a reference group (75.6 vs 69.9 years). The same group also showed that the rate of hospitalisation later in life was lower for endurance sports and power sports compared with the reference group.² This resulted from a lower rate of hospital care for heart disease, respiratory disease and cancer. However, the athletes were more likely to have been hospitalised for musculoskeletal disorders. Thus, the evidence suggests that although there is a general health benefit from sports participation, injuries represent a significant side effect.

One priority of the International Olympic Committee (IOC) is to protect the health of the athlete. During recent years, prevention of injuries and illnesses has been high on the IOC agenda. During the Athens Games, an injury surveillance system was applied for all team sports.³ During the Beijing Games, the IOC ran,

for the first time, an injury surveillance system covering all the athletes, showing a 10% incidence of injuries.⁴ In Vancouver and London, the surveillance system will include disease conditions as well. The surveillance studies are prerequisites for providing evidence for health development in sports as well as for developing prevention programmes. Another method to decrease injuries and diseases in the elite athlete is to perform a preparticipation examination (PPE) or periodic health evaluation (PHE) of all elite athletes.⁵ PHE in various forms have been available for many years, but a recent analysis⁵ has questioned the efficacy of PHEs in detecting serious problems in the elite athlete.

In March 2009, the IOC assembled an expert group to discuss the current state of health evaluations for athletes, aiming to provide recommendations for a practical PHE for the elite athlete, as well as to outline the need for further research. The task of the group was to review the benefits as well as potential negative effects of PHE at the elite sport level. The group did not take any position as to whether PHE should be recommended as compulsory for participation in sport. That is for the relevant sports authorities to decide.

The PHE can serve many purposes. It includes a comprehensive assessment of the athlete's current health status and risk of future injury or disease and, typically, is the entry point for medical care of the athlete. The PHE also serves as a tool for continuous health monitoring in athletes. Recent advances in this field relate to: (1) data on sudden cardiac death and other non-cardiac medical problems, and the detection of risk factors and groups; (2) a consensus conference on concussion; (3) data on eating disorders; and (4) data on risk factors for musculoskeletal injuries. This paper addresses each of these advances in more detail after a discussion on the purpose of a PHE and the evidence we have supporting the different components of the PHE.

PURPOSES OF THE MEDICAL EVALUATION

In a narrow sense, the main purpose of the PHE is to screen for injuries or medical conditions that may place an athlete at risk for safe participation. Athletes may be affected by conditions that do not have overt symptoms and that can only be detected by periodic health evaluations. One example is cardiovascular abnormalities, such as hypertrophic cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy or congenital coronary arteries

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anomalies. These are typically silent until a potentially fatal arrhythmia occurs but may in some cases be detected through a careful cardiovascular examination.

Screening is a strategy used in a population to detect a disease in individuals without signs or symptoms of that disease. The intention is to identify pathological conditions early, thus enabling earlier intervention and management in the hope of reducing future morbidity and mortality. Although screening may lead to an earlier diagnosis, not all screening programmes have been shown to benefit the person being screened.

To ensure that screening programmes confer the intended benefit, the World Health Organization published what have become known as the Wilson–Jungner criteria for appraising a screening programme.⁶ The main criteria are that the condition being screened for is an important health problem (depending not just on how serious the condition is, but also how common it is), that there is a detectable early stage, that treatment at an early stage is of more benefit than at a later stage and that a suitable test is available to detect disease in the early stage.

From a public health perspective, there is insufficient evidence to date to mandate any specific screening tests for elite athletes apart from those recommended for the general population. This is mainly the consequence of the low risk of serious conditions in this population. An important limitation is also the lack of suitable screening tests; such tests must be reliable (repeatable, good interobserver agreement), sensitive (detects all those with increased risk), specific (detects only those with increased risk), affordable (ideally cheap, easy to perform, widely available), acceptable to the screening population and subject to quality assurance.

However, the PHE may serve other purposes than just screening athletes for future health problems. One obvious goal is to ensure that current health problems are managed appropriately and, ultimately, to determine whether an athlete is medically suitable to engage in a particular sport or event. Even elite athletes with easy access to medical care do not always seek medical attention for injuries or disease, despite having significant symptoms.

Some silent conditions are common and, although not severe from a health perspective, may influence sports performance. An example of this is mild iron deficiency, which is common in female athletes. Periodic health evaluations and ongoing monitoring represent an opportunity to diagnose and manage such

conditions. They also provide an opportunity to identify conditions that are barriers to performance. An example is astigmatism, which can be detected on a simple test of visual acuity. Another important function of periodic health evaluations is that they allow the athlete an opportunity to establish a relationship with the health personnel who will be involved in providing continuing care.

Finally, the PHE also represents an opportunity to look for characteristics which may put the elite athlete at risk for future injury or disease. However, as mentioned above, there is limited direct evidence to suggest that it is possible to predict future outcomes based on the PHE. Nevertheless, there is evidence in some areas, such as injury risk factor assessment,⁷ that holds future promise and warrants investigation related to the PHE. Depending on the sport and the age, ethnic origin and gender of the athlete, it may be prudent to include an assessment of specific risk factors in the PHE.

GENERAL REQUIREMENTS OF A PHE

It is important to address and balance the ethical and legal aspects of the PHE in order to help protect the rights and responsibilities of athletes, physicians, sporting organisations and other persons concerned. In the context of designing and implementing a PHE, the following considerations need to be taken into account:

- ▶ PHE should be based on sound scientific and medical criteria.
- ▶ PHE should be performed in the primary interest of the athlete, that is, assessing their health in relation to their practice of a given sport.
- ▶ PHE should be performed under the responsibility of a physician trained in sports medicine, preferably by the physician responsible for providing ongoing medical care for the athlete—for example, the team physician.
- ▶ The decision concerning the nature and scope of the PHE should take into account individual factors, such as the geographical region, the sport discipline, the level of competition, age and gender of the athlete.
- ▶ The setting of the evaluation should be chosen to optimise the accuracy of the examination and respect the privacy of the athlete. The PHE should preferably be carried out in the physician's office, which assures privacy, access to prior medical records and an appropriate patient–physician relationship.
- ▶ A physician can only perform a PHE with the free and informed consent of

the athlete and, if applicable, their legal guardian.

- ▶ If PHE evidences that an athlete is at serious medical risk, the physician must strongly discourage the athlete from continuing training or competing until the necessary medical measures have been taken.
- ▶ Based on such advice, it is the responsibility of the athlete to decide whether to continue training or competing.
- ▶ If a physician is requested to issue a medical certificate, they must have explained in advance to the athlete the reason for the PHE and its outcome, as well as the nature of information provided to the third parties. In principle, the medical certificate may only indicate the athlete's fitness or unfitness to participate in training or competition and should minimise disclosure of confidential medical information.

In many settings, the PHE is used to offer medical clearance to participate in sport and is seen as a one-time certification for future involvement in elite sport. However, the evaluation of the athlete's health should ideally be seen as a dynamic, ongoing process.

While many aspects of the PHE will be common to all elite athletes, it should be tailored to be gender, age, race, culture and sport specific when appropriate. If any injury or medical condition is identified, it should be managed in a manner consistent with the existing standards of medical care. If warranted, this may involve referral to the appropriate specialists for further evaluation and management. It should be noted that the PHE is also the time that medications or nutritional products in use or prescribed should be reviewed to determine if a Therapeutic Use Exemption (TUE) application to the World Anti Doping Association (WADA) is needed.

The timing of the PHE should ideally allow for sufficient time for management of any injuries or medical problems well before major competitions. For example, it is preferable to conduct a PHE during the off-season so that rehabilitation or other treatment can restore the athlete to optimal health before facing maximal physical stress.

As the PHE is the only contact that many elite athletes will have with medical personnel, it should be seen as an opportunity for education regarding other health risks and health-related behaviour.

The following document is laid out in sections that correspond to the various areas of evaluation appropriate to the elite athlete.

1. CARDIOLOGY

1.1 Introduction

The scope of the cardiovascular PHE is to detect potentially lethal cardiovascular disease in elite athletes and start appropriate management to reduce the risk for sudden cardiac death and/or disease progression in a timely fashion.

1.2 Evidence base

Cardiovascular (CV) risk of competitive sport participation

Regular participation in training and athletic competition is associated with an increased risk for sudden cardiac death (SCD), with an average relative risk for athletes of 2.8 times compared with their non-athletic counterpart.⁸ It is worth noting, however, that sport is not per se the cause for greater incidence of SCD. It is the combination of intensive physical exercise in athletes with underlying cardiovascular disease, which can trigger ominous arrhythmias leading to cardiac arrest. The relative risk of sport participation is different according to the underlying disease, and it is greatest in case of cardiomyopathies (such as hypertrophic cardiomyopathy or arrhythmogenic right ventricular cardiomyopathy) or congenital coronary arteries anomalies (Corrado *et al* 2003).

Rationale for CV evaluation in elite competitive athletes

The vast majority of the athletes dying suddenly do not experience premonitory symptoms;⁹ therefore, the PHE represents the only strategy capable of identifying athletes with silent cardiac disease, and allowing appropriate management to reduce the risk of SCD and disease progression. Identifying asymptomatic athletes with underlying cardiovascular disease through the PHE is important because SCD could be prevented by lifestyle modification, including (when necessary) restriction from competitive sports activity, but also prophylactic treatment by drugs, implantable cardioverter defibrillator (ICD) or other therapeutic options. Athletes carrying an increased cardiac risk may have a favourable long-term outcome thanks to timely identification and appropriate clinical management.¹⁰

Rationale for including the 12-lead ECG in the PHE

Recent scientific evidence supports the role of ECG in reducing mortality in screened athletes.¹¹ This concept is based on the recognition that ECG is abnormal

in most individuals with hypertrophic cardiomyopathy (up to 90%) and arrhythmogenic right ventricular cardiomyopathy (up to 80%). The ECG can also identify athletes with WPW syndrome and ion channel diseases, such as Lènegre conduction disease, long or short QT syndromes and Brugada syndrome.¹²⁻¹³ However, there has been criticism voiced related to available data on the use of ECG in the elite athlete based on lack of an unscreened athletic control group. A comparison of athletes screened with ECG versus non-screened athletes will require two matched large athlete populations (several thousand athletes, in consideration of the low incidence of cardiomyopathies) undergoing long-term follow-up (at least two decades, due to the young age of athletes at initial evaluation).

It has been demonstrated that adding a 12-lead ECG examination to history and physical examination results in a substantial increase in the ability to identify potentially lethal heart disorders,¹²⁻¹³ and this strategy has been endorsed in "The Lausanne Recommendations"¹⁴ and the European Society of Cardiology recommendations.¹⁵ However, it is not currently recommended by the American Heart Association.¹⁶⁻¹⁷

1.3 Proposal for PHE

The following questions regarding cardiovascular abnormalities should be included:

Family history:

Family history of one or more relatives with disability or death of heart disease (sudden/unexpected) before age 50.

Family history of cardiomyopathy, coronary artery disease, Marfan syndrome, long QT syndrome, severe arrhythmias, or other disabling cardiovascular disease.

Personal history:

syncope or near-syncope;

exertional chest pain or discomfort;

shortness of breath or fatigue out of proportion to the degree of physical effort;

palpitations or irregular heartbeat.

Physical examination should be performed according to the best clinical care and should investigate the presence of:

musculoskeletal and ocular features suggestive of Marfan syndrome;

diminished and delayed femoral artery pulses;

mid- or end-systolic clicks;

abnormal second heart sound (single or widely split and fixed with respiration);

heart murmurs (systolic grade >2/6 and any diastolic);

irregular heart rhythm;

brachial, bilateral blood pressure >140/90 mm Hg on more than one reading.

Twelve-lead ECG

The 12-lead ECG should be recorded on a non-training day, during rest, according to best clinical practice. Interpretation of the ECG abnormalities can be categorised according to the criteria defined by Corrado *et al*¹⁸ into two groups: (1) the most common in trained athletes (sinus bradycardia, first degree AV block, notched QRS in V1 or incomplete right bundle branch block, isolated QRS voltage criteria for LV hypertrophy) consistent with athlete's age, ethnical origin and level of athletic conditioning, and that do not require additional testing; (2) all other less common ECG abnormalities further evaluated to exclude cardiovascular disease (fig 1).

Further investigations

At present, there is no agreement regarding the need for routine use of echocardiography in the PHE. Neither is there a role for routine use of other imaging or invasive testing. However, in the presence of abnormal findings at history, physical examination or 12-lead ECG, additional testing should be performed in order to confirm (or exclude) cardiovascular disease. In most instances, echocardiography is the first-line test, but other imaging modalities (such as cardiac magnetic resonance) or invasive testing, when necessary, may be pursued. In adult athletes (>35 years) exercise ECG testing in the context of PHE is efficient to detect otherwise unsuspected cardiac abnormalities¹⁹ and is currently recommended for elite athletes with increased cardiovascular risk profile.²⁰

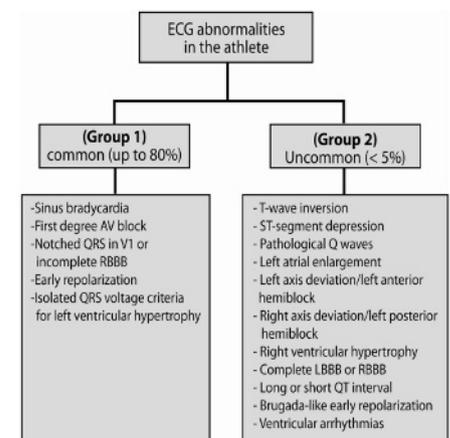


Figure 1 Twelve-lead ECG abnormalities.

1.4 Management of athletes with CV abnormalities

The IOC PHE Consensus Group recommends that any athlete identified with a CV abnormality should be managed according to the current, widely accepted clinical recommendations, that is, Bethesda Conference #36 and ESC recommendations.^{21 22} The group acknowledges that identification of cardiac disease in an athlete represents a challenging question regarding the ethical, medical and legal consequence with particular regard to the need for disqualification from competition. However, there is scientific evidence that preventing athletes with specific cardiovascular abnormality from regular training and competition is an efficient strategy for preventing SCD.^{10 23} Unnecessary exclusion from participation of competitive athletes with non-lethal diseases is a problem. Therefore, there is a need for a common agreement of sports eligibility guidelines and management of competitive athletes with cardiovascular diseases in the future.²⁴ The main goal should be to reduce the number of unnecessary disqualifications and to adapt (rather than restrict) sports activity in relation to the specific cardiovascular risk.

Finally, we recognise that young competitive athletes (<18 years) require specific expertise in the evaluation, interpretation of findings and management.

1.5 Educational programmes

The sport organisations together with scientific sport societies should encourage and support educational activities intended to enhance the knowledge and skill of physicians involved in the cardiology part of the PHE process.

1.6 Research

Although there are issues of debate regarding wide-scale mandatory use of the ECG for athlete screening,^{16 24} there is sufficient evidence to justify a staged implementation with evaluation to assess the properties of the test (sensitivity, specificity, predictive value) in a variety of sporting populations. Staged implementation would provide a natural control group to measure differences in outcome between ECG screened and unscreened groups. Finally, the mortality effects of a screening programme documented in Italy need to be replicated in other ethnic populations where the underlying disease conditions may differ from those seen in Italy.

The sport organisations and scientific sport societies should encourage research

that could expand our current knowledge and database regarding the mechanisms and strategies to prevent SCD in competitive athletes.

2. NON-CARDIAC MEDICAL CONDITIONS

2.1 Introduction

To date, the main elements of the PHE have been to screen elite athletes for possible risk for sudden cardiovascular death,^{15 25} musculoskeletal injury,²⁶ and head injury.²⁷ Furthermore, elements of the PHE that focus on non-cardiac medical conditions have to date been confined to haematological conditions,²⁸ lung disease, particularly exercise-induced bronchoconstriction²⁹ and specific medical concerns of the female athlete.³⁰

However, sports physicians who regularly perform medical assessments on elite athletes, as well as members of the medical team that accompany athletes to the Olympic Games (fig 2) and other international sports events, commonly encounter medical conditions that are non-injury-related, and are of a non-cardiac nature.³¹⁻³³

In one study, it was reported that 50% of the 1804 athletes seen at the multi-purpose medical facility at the 1996 Olympic Games were treated for non-injury-related illnesses.³⁴ In another study conducted in the athlete medical clinic during the 2002 Winter Olympic Games, medical diagnoses, notably respiratory conditions, were more commonly reported than traumatic conditions.³³ Furthermore, in two other studies, over 50% of the medical consultations in a participating team during two Olympic Games were non-injury-related.^{31 32} It is important to note that the frequency of cardiac-related medical consultations reported in these two studies was very low.^{31 32}

Therefore, medical conditions in systems other than the cardiovascular system are very common in elite athletes. These conditions can occur immediately before competitions, during periods of training in preparation for competitions and after competitions. In two reports, the fre-

quency of medical conditions reported in athletes during the Olympic Games has been documented (table 1). These data indicate that medical conditions, other than cardiovascular conditions, are common in elite athletes, yet these conditions have not received much attention in a PHE. A spectrum of medical conditions can occur in athletes across a number of medical systems (box 1), and these can be identified during a PHE.^{35 36} Finally, a number of these conditions are transient and can be treated. Therefore, clearance for sports participation when athletes suffer from these conditions is an ongoing process and requires ongoing monitoring and assessment.

The purpose of this section is to (1) briefly review the evidence base for including elements in the PHE that focus on non-cardiac medical conditions; (2) recommend elements in the medical history, physical examination and special investigations that could be included in a PHE to identify significant non-cardiac medical conditions; and (3) suggest future directions for research in this area.

2.2 Evidence base: non-cardiac medical conditions

There are very few data available on the inclusion of assessment for non-cardiac medical conditions in a PHE. Evidence for the inclusion of screening tests to identify non-cardiac medical conditions in a PHE is therefore largely limited to expert opinion and case series. However, the identification of some non-cardiac medical conditions is frequently included in the medical history, physical examination and profile of special investigations of existing PHE recommendations.³⁷⁻⁴² The evidence base for including screening to identify non-cardiac medical conditions in a PHE will be briefly reviewed below.

2.2.1 Pulmonary system

The rationale for including an assessment of the pulmonary system in a PHE is that respiratory symptoms that are suggestive of asthma are common in athletes.⁴³ At the time of a PHE, these symptoms can be identified, and the clinical examination together with objective special tests can be used to confirm the diagnosis of asthma.⁴³ The prevalence of asthma in athletes is high and varies from 3–23% in summer sports to 12–50% in winter sports.^{44 45} Furthermore, during a PHE, respiratory-tract conditions other than asthma that can also give rise to respiratory symptoms in athletes can be identified.⁴⁵



Figure 2 Olympic rings.

Table 1 Frequency (percentage of all formal medical consultations) of medical consultations at the Olympic Games in a team

	Sydney 2000 Olympic Games ^a	Athens 2004 Olympic Games ^a
Ear, nose and throat (%)	18	13
Pulmonary (respiratory) (%)	16	8
Nervous system (neurological) (%)	16	4
Gastro-intestinal (%)	6	6
Dermatological (%)	2.5	16
Urological (%)	2.5	0
Psychological/psychiatric (%)	2	3
Cardiology (%)	1	3
Ophthalmological (%)	0.5	0.5
Other (%)	4.5	6

2.2.2 Haematological

The main rationale for including routine haematological assessment during a PHE is based on the higher-than-expected prevalence of decreased iron stores in athletes, particularly female athletes.^{28 46-52} An additional rationale is to determine if the athlete has anaemia (iron deficiency or other), and to identify other illnesses such as infections.²⁸ It is noteworthy that haematological testing has been suggested as a screening/monitoring tool for blood doping (haematological passport) as well.⁵² The likelihood of a positive result on routine haematological screening is higher in physically active females than in male athletes.^{28 48 53}

2.2.3 Allergies

The rationale for including assessments in the PHE to identify allergies, particularly allergic rhinoconjunctivitis, in elite athletes is based on the facts that (1) significantly higher than expected prevalence of allergic conditions has been observed in elite athletes;⁵⁴⁻⁵⁷ (2) travelling athletes could be exposed to a variety of allergens at different venues where international competitions take place;⁵⁵ and (3) acute and chronic allergies could result in morbidity and also reduce athletic performance.⁵⁸

2.2.4 Infections and immunological

The rationale to consider infective disease in a PHE is based on a number of important considerations. First, it is established that during intense training and immediately following competitions, there is evidence of immune suppression in athletes that could predispose them to infective disease.^{59 60} Second, acute systemic infective illness is a contraindication to participation in sports because of the risk of viral myocarditis, organ injury (splenomegaly) and in some cases increased risk of transmission of the infective illness to fellow athletes.⁶¹⁻⁶³

Third, the PHE provides an opportunity to assess whether an athlete has been immunised against infective conditions, including those that may be associated with international travel to specific regions. There are a number of infective illnesses that could be considered when performing a PHE, and these have been reviewed recently.^{61 62}

2.2.5 Ear, nose and throat

The rationale for including the ear, nose and throat (ENT) assessment in a PHE is based on the high incidence medical consultations during international competitions that are related to this system in elite athletes (table 1). Furthermore, the common illnesses encountered in the ENT system of athletes are allergies^{54 58} and upper-respiratory-tract infections.^{33 60 61 64} The basis for including this spectrum of conditions in PHE has already been discussed.

2.2.6 Dermatological

The rationale for including a dermatological assessment in the PHE is that skin disorders are very common in athletes.⁶⁵⁻⁶⁷ Furthermore, participation in sports may predispose athletes to certain skin conditions, and there is a risk of transmission of certain skin conditions during sports.⁶⁵ Therefore, clearance to compete may have to be withheld temporarily if athletes suffer from some skin infections.⁶⁵

2.2.7 Urological

The rationale for including an assessment of the urological system in the PHE is not based on strong evidence. However, it is known that (1) renal and bladder disease can be asymptomatic; and (2) conditions such as asymptomatic haematuria, proteinuria and pyuria are often encountered when screening in athletes is conducted.⁶⁸ Although these conditions may not be clinically significant, they do however

require further evaluation to exclude underlying urological disease.

2.2.8 Gastro-intestinal

The rationale for including an assessment of the gastro-intestinal (GIT) system in the PHE is that GIT symptoms are very common in athletes (particularly endurance athletes) during sports participation.⁶⁹ Exclusion of significant underlying GIT disease is therefore important in athletes, particularly those that regularly suffer from GIT symptoms during exercise.⁶⁹ Furthermore, GIT conditions are also frequently encountered when travelling with athletes to international competitions.^{31 32}

2.2.9 Nervous system (neurological)

The rationale for including assessment of neurological conditions in the PHE of athletes is that neurological conditions are common⁷⁰ and can include a variety of different conditions such as headaches and epilepsy. Furthermore, although uncommon, stroke can occur in younger adults, including athletes. It has been suggested that the PHE should include screening for the risk factors of stroke in young athletes.⁷⁰

2.2.10 Endocrine/metabolic

The rationale for routine enquiry to determine if elite athletes have underlying endocrine and metabolic disease is (1) that these conditions do occur in elite athletes; (2) one of the more common endocrine conditions in elite athletes is diabetes mellitus—nine Olympic athletes required therapeutic use exemption for the use of insulin in the 2004 Summer Olympic Games;⁷¹ and (3) elite athletes with existing endocrine and metabolic disease may require counselling and advice because medication they may use could contravene doping control regulations.⁷²

2.2.11 Ophthalmology

The principal rationale for including ophthalmological assessment in the PHE is that ophthalmic conditions, particularly reduced visual acuity, have been reported in 4.5–25% of college athletes undergoing a PHE.^{35 36 73} Other less common ophthalmological conditions can also be identified.

2.3 Proposal for content of the PHE

Assessment of non-cardiac medical conditions during a PHE would include an appropriate systematic medical history (table 2). A directed physical examination

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and selected special investigations (table 3) should follow. Routine investigations that are recommended are (1) urinalysis (males and females) and (2) tests for iron stores (female athletes). According to best-medical-practice guidelines, these elements should be included in the PHE to assess elite athletes for the presence of non-cardiac medical conditions.

2.4 Possible future directions in research

Broad research areas:

- ▶ Define the scope of the problem in each system (prevalence of non-cardiac medical conditions in elite athletes).
- ▶ Determine the impact of these medical conditions on performance, short-term risk and longer-term outcome in elite athletes.
- ▶ Investigate which diagnostic tests have the highest sensitivity, specificity and predictive value for each condition.
- ▶ Determine if identification and management of these conditions reduces morbidity and improves performance in elite athletes.

3. CONCUSSION IN SPORT

3.1 Introduction

Concussion in sport is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces.⁷⁴ Estimates in the USA range from 1.6 to 3.8 million concussions per year related to sport and recreation.^{75 76} There is evidence that concussions are particularly prevalent in collision sport.^{77 78}

3.2 Evidence base

The IOC and several members of the present consensus group participated in the recent Zurich Consensus Statement on Concussion in Sport⁷⁹ and endorse its concepts and principles. A structured consensus-development conference format was used, modelled after the protocol of the National Institutes of Health, including development of evidence-based recommendations. The specific evidence and rationale are provided in detail in the manuscript by McCrory *et al.*

3.3 Proposal for content of the PHE

It is recognised that a structured concussion history is an important component

of the PHE and should include specific questions regarding:

- ▶ previous symptoms of a concussion; not just the perceived number of past concussions; appreciating the fact that many athletes will not recognise all the concussions they may have suffered in the past;
- ▶ all previous head, orofacial or cervical spine injuries;
- ▶ whether repeated concussions produce disproportionate severity of symptoms given the amount of impact; alerting the clinician to a progressively increasing vulnerability to injury;
- ▶ use of protective equipment such as helmets, facial protection and mouth guards; including their age and state of repair;
- ▶ the ability of the athlete to adopt protective behaviour such as avoiding overly aggressive or high risk situations.

The purpose in obtaining such a history may identify athletes that fit into a high-risk category and provides an opportunity for the healthcare provider to educate the athlete in regard to the significance of concussive injury.

3.4 Possible future directions for concussion in sport

The Concussion in Sport Group⁷⁹ had extensive discussion and general agreement on the principle of doing baseline assessment (neuropsychological, balance, etc) during the PHE in high-risk sports. The intent is to provide a comparison point for possible future postinjury testing. While a specific recommendation for baseline examination in the PHE was not included in the concussion consensus document, one of the suggested future directions in research was the "clinical assessment where no baseline assessment has been performed."⁷⁹

4. DENTAL INJURIES

4.1 Introduction

Oral health evaluation has significant relevance to the establishment of an improvement in oral health. Good oral health will ensure good function and the ability of the athlete to compete at an optimal level without being compromised by dental disease or an otherwise preventable emergency.

4.2 Evidence base

Statistics collected by the IOC at recent summer games⁸⁰ have highlighted the level of dental disease in many partici-

Table 2 List of suggested questions in the medical history to identify non-cardiac conditions in a periodic health evaluation

	Suggested question/s in the medical history*
Pulmonary system	Do you have a past history or currently suffer from any symptoms of respiratory (lung) disease including asthma, wheezing, cough, postnasal drip, hay fever or repeated flu-like illness?
Haematological system	Do you have a past history or currently suffer from any symptoms of disease of the blood system including low iron stores, anaemia (in particular iron-deficiency anaemia)?
Allergies	Do you have a past history or currently suffer from any symptoms of allergies including allergies to pollen, foods, medication, any plant material or any animal material?
Infection/immunological	Do you have a past history or currently suffer from any symptoms of disease of the immune system including current infections, recurrent infections, HIV/AIDS or leukaemia, or are you using any immunosuppressive medication?
Ear, nose, throat (ENT)	Do you have a past history or currently suffer from any symptoms of disease of the ears (infections, hearing loss, pain), nose (sneezing, itchy nose, sinusitis, blocked nose) or throat (sore throat, hoarse voice, swollen glands in the neck)?
Dermatological	Do you have a past history or currently suffer from any symptoms of skin disease including skin rashes, skin infections, itchy skin, allergies or skin cancer?
Urological	Do you have a past history or currently suffer from any symptoms of disease of the kidney or bladder including past history of kidney or bladder disease, blood in the urine, loin pain, kidney stones, frequent urination or burning during urination?
Gastrointestinal	Do you have a past history or currently suffer from any symptoms of gastrointestinal disease including heartburn, nausea, vomiting, abdominal pain, weight loss or gain (>5 kg), a change in bowel habits, chronic diarrhoea, blood in the stools or past history of liver, pancreatic or gall-bladder disease?
Neurological	Do you have a past history or currently suffer from any symptoms of diseases of the nervous system including past history of stroke or transient ischaemic attack, frequent headaches, dizziness, blackouts, epilepsy, depression, anxiety attacks, muscle weakness, nerve tingling, loss of sensation, muscle cramps or chronic fatigue?
Endocrine/metabolic	Do you have a past history or currently suffer from any symptoms of metabolic or hormonal disease including diabetes mellitus, thyroid gland disorders, hypoglycemia (low blood sugar) or heat intolerance?
Ophthalmological	Do you have a past history or currently suffer from any symptoms of eye disease or injury including decreased vision, pain in the eyes, itchy eyes, increased or decreased tear production, discharge from the eye or red eyes?

*If the answer to any of these questions is "yes," further details and directed in-depth assessment are required.

Table 3 Key elements in the physical examination for non-cardiac conditions in a PHE

	Selected key components in the physical examination*
Pulmonary system	Comprehensive examination including assessment of chest including percussion, and auscultation
Haematological system	Comprehensive examination including assessment for pallor, and evidence of infections
Allergies	Comprehensive examination for manifestations of acute and chronic allergy
Infection/immunological	Comprehensive examination for lymphadenopathy, splenomegaly
Ear, nose, throat (ENT)	Comprehensive examination including external auditory canal, tympanic membrane, sinus tenderness, nasal septum, turbinate bones, oropharynx, tonsils, indirect laryngoscopy (if indicated), cervical and regional lymphadenopathy
Dermatological	Comprehensive examination of sun exposed areas, assessment of skin infections (fungal)
Urological	Comprehensive examination including assessment for suprapubic tenderness, abdominal examination for renal masses, genital examination (males)
Gastro-intestinal	Comprehensive abdominal examination for including assessment for abdominal tenderness, organomegaly and hernias
Neurological	Comprehensive examination including assessment of cranial nerve function, motor function, sensory function, reflexes and the extrapyramidal system
Endocrine/metabolic	Comprehensive examination including assessment for the complications of diabetes mellitus and the clinical signs of thyroid disease
Ophthalmological	Comprehensive examination including assessment of visual acuity, visual fields, infective and allergic eye disease, funduscopy

*The list of suggested physical signs is not intended to be comprehensive but is to serve as a guideline. If a positive finding is identified, further in-depth assessment with appropriate special investigations is required.

pants. The use of a DMF Index (“decayed–missing–filled,” a dental screening tool) and appropriate radiographs to measure dental disease may also identify oral health behaviour and the extent of poor oral health prevalent in our elite athlete group.^{81 82} The identification of erosion, the prevalence of which is estimated to be 25.4–37.4% in athletes, may be an indicator of excessive use of sports beverages, which are acidic in nature.^{83 84} In addition, erosion may be caused by acidic reflux, which may be indicative of an underlying eating disorder.^{85 86}

The presence of wisdom teeth^{87 88} and certain malocclusions are risk factors for future injury.^{89 90} The presence or absence of wisdom teeth may affect the risk profile for mandibular fracture in combative sports.^{91–93} Additionally, associated pericoronitis and periodontal infection may affect athlete performance.⁹⁴

4.3 Proposal for content of the PHE

The physical examination should include the following elements:

- ▶ DMF, an acronym for decayed, missing and filled teeth; these three elements together with recent dental history can be used as an indicator for underlying oral health.

Other risk factors for orofacial injury that can be targeted for prevention are:

- ▶ malocclusion where the overjet (overlap of upper over lower incisors) is greater than 6 mm;^{89 90}

- ▶ presence of braces or orthodontic appliances.⁹⁵

4.4 Possible future directions in oral health

Efforts should be made to educate athletes and authorities about the considerable benefits in preventing dental injuries by providing custom-made mouthguards for those taking part in “at risk” sports (eg, collision and contact sports),^{91 96} and to continue to measure or quantify the benefits. Additionally, further studies are required to assess more accurately the oral health of the athlete population, and educational programmes should be expanded and targeted to those sports where the risks identified above influence athlete health.^{97 98} The IOC group encourages athletes to be provided with regular dental examinations

5. MUSCULOSKELETAL INJURIES

5.1 Introduction

Musculoskeletal injuries are common in sports. Acute injuries are most common in sports in which the speed is high, and the risk of falling is great (eg, downhill skiing), and in team sports where there is significant contact between players (eg, ice hockey and soccer). Overuse injuries make up the large portion of injuries in aerobic sports that require long training sessions with repetitive motion (eg, long-distance running, cycling or cross-country skiing). However, a large number of overuse injuries also occur in technical sports, in which the same movement is repeated numerous times (eg, tennis, javelin

throwing, weightlifting and high jumping). The injury profile also varies from sport to sport; each sport has its distinctive injury pattern. This pattern must be considered carefully when designing the musculoskeletal component of the PHE. The practitioner must be familiar with the most common injury types associated with the sport in question, and the examination should be targeted on these injury types and their risk factors.

The main objective of the musculoskeletal PHE is to detect current injuries and ensure that these are managed appropriately. While an injured athlete may have gone through rehabilitation in the middle of the season, the focus is often on return to play, sometimes using taping and bracing to protect from further injury. The off-season should be used as an opportunity to get the athlete back to full fitness. Therefore, the best timing of the PHE may be the immediate postseason (while there is still time to work on problems that are identified) rather than the preseason.

A previous injury is the most consistent risk factor for new recurrent injuries. This has been demonstrated for a number of different injury types, such as ankle sprains, muscle strains and knee ligament injuries. A previous injury could compromise joint function through reduced mechanical stability or neuromuscular control, or muscle function through scar tissue formation, reduced strength, or more subtle changes in the length–tension relationship. It follows, then, that training programmes to restore strength and neuromuscular control can help prevent recurrent injuries. One important aim of the musculoskeletal PHE is therefore to identify sequelae or deficits resulting from previous injuries.

Ideally, the musculoskeletal PHE should be used to identify athletes at risk for injury. However, although a number of risk factors have been identified which make an athlete susceptible to different injuries, the examination needs to be focused on the characteristics and requirements of the sport in question. A complete review of risk factors associated with injuries to the different body regions can be found in the IOC Handbook on Sports Injury Prevention.⁷

5.2 Evidence base

The evidence base for designing a musculoskeletal PHE to detect risk factors for future injury is limited. Players with a history of previous injury or symptoms indicating reduced function are a group with an increased injury risk that should

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be targeted for soft-tissue examinations and with specific prevention programmes addressing their deficits. However, in the asymptomatic athlete with no history of previous injury, there is limited evidence to prescribe specific tests—even using more advanced functional tests—to identify athletes at risk. One limitation is that the reproducibility of such tests is often low. Another is that the predictive value of such tests is for the most part unknown.

5.3 Proposal for the content of the PHE

The fundamental element of the musculoskeletal PHE is obtaining a thorough history of current and previous musculoskeletal injuries. To improve the history, one can use self-report forms; these should be specific to the regions and injury types associated with the sport in question to ensure that no injuries and symptoms are missed. The clinical examination should follow up on any symptoms or injuries reported, consisting of inspection, palpation, range of motion, strength and laxity exams, effusions, muscle testing and relevant functional exams. Additional imaging (eg, ultrasound, MRI) or more advanced functional tests (eg, strength tests, balance tests) may be indicated based on history and physical examination.

5.4 Possible future research directions

Large-scale population-based studies are needed to evaluate the components of history and examination that can be used to identify athletes at risk, intervene and change outcome.

6. PHE ISSUES SPECIFIC TO WOMEN

6.1 Introduction

Female athlete participation in sport has increased tremendously, with 42% of the athletes at the Beijing Olympic Games being female.⁹⁹ Despite the well-documented health benefits of exercise, there are two medical conditions unique to the female athlete that may have long-term consequences that can be avoided through early detection and treatment. Low energy availability from caloric intake inadequate to meet the energy requirements of exercise can lead to secondary menstrual disorders and low bone density. This is referred to as the female athlete triad.¹⁰⁰ In addition, iron-deficiency anaemia is more common in the female athlete.¹⁰¹ The health and performance consequences of these two conditions can be prevented through early detection and treatment. The PHE provides a unique opportunity for the team physician to

detect and treat low energy availability, menstrual disorders, low bone density and iron-deficiency anaemia.

6.2 Evidence base

The prevalence of eating disorders (anorexia nervosa (AN), bulimia nervosa (BN), anorexia athletica (AA) and eating disorders not otherwise specified (ED-NOS)) in the sport population was found to be 15–31% in comparison with 5–13% in the general population. The prevalence in males is generally lower than in females.^{102–103} The sports at highest risks are the aesthetic sports that emphasise thinness, endurance sports and weight class sports.¹⁰² The prevalence of secondary amenorrhea varies widely depending on the type of sport and is reported to be as high as 65% in long-distance runners¹⁰⁴ in comparison with 2–5% in the general population.¹⁰⁵ The incidence of secondary amenorrhea increases with weekly mileage,¹⁰⁶ with athletes in sports emphasising leanness¹⁰⁷ and in athletes less than 15 years of age.¹⁰⁸ The incidence of primary amenorrhea is 22% in cheerleading, diving and gymnastics¹⁰⁹ in comparison with <1% in the general population.¹¹⁰ Likewise, the frequency of low bone mineral density in athletes is two to four times greater than the general population.¹¹¹ Stress fractures occur more frequently in athletes with abnormal menstrual cycles and low bone mineral density.¹¹² Short- and long-term consequences of the female athlete triad are well documented in the literature and effective treatment exists.¹⁰⁰

For the detection of eating disorders and disordered eating, several validated screening tools exist: the Eating Disorder Examination Questionnaire (EDE-Q),^{113–115} the SCOFF Questionnaire^{116–7} and the Eating Disorder Screen for Primary Care (ESP).¹¹⁸ A comparative study of the SCOFF and ESP screening tools by Cotton *et al* identified four questions that could serve as positive predictors and two as negative predictors of disordered eating (table 1, included in appendix A PHE Form).¹¹⁸ A population of high school endurance runners with low bone mineral density was found to score higher on the EDE-Q subscale of Dietary Restraint in comparison with other subscales. The validated questions correlating caloric restriction and low bone mineral density are shown in box 2.¹¹⁹

6.3 Proposal for content for the PHE

The history and physical examination of the female athlete should address each component of the female athlete triad.

Validated questions to detect eating disorders and disordered eating should be utilised (box 2). Assessment of menstrual pattern and a history of stress fractures should be included. A systems review may identify body systems affected by low energy availability. If so, completion of a nutritional analysis identifies the athlete at risk for energy imbalance and iron deficiency.

A physical examination should include a body mass index. The following physical signs can be found in advanced cases of eating disorders but are likely to be absent in early detection: lanugo, petechiae, subconjunctival haemorrhages, swelling of the parotid glands, erosion of tooth enamel, bradycardia and peripheral oedema. A complete gynaecological examination is recommended in the athlete with primary or secondary amenorrhea.

The laboratory examination should include a CBC for all female athletes and a serum ferritin for those athletes in endurance sports. For those athletes identified at risk for the female athlete triad based on a screening questionnaire, physical examination abnormalities and initial blood work, measurement of body composition is recommended. For these athletes, laboratory tests include a hormonal screen (TSH, LH, FSH, estradiol, prolactin, beta HCG, testosterone, 17-OH-progesterone, sex hormone binding capacity, cortisol, DHEA-S, androstenedione), CBC, biochemistry screen, bone mineral density (iDXA scan) to assess bone health, ECG to rule out electroconductive abnormalities from electrolyte disturbance in eating disorders and a nutritional analysis to assess energy balance.

6.4 Future direction

6.4.1 Research

Further research should be directed toward ascertaining the cause-effect relationship between the female athlete triad and sports participation. Validating the questions for detecting the triad is essential for accurate diagnosis and for earlier identification of athletes who would benefit from intervention. Further research into the relationship between low ferritin as a premonitor of iron deficiency anaemia is important for both medical and performance reasons.

6.4.2 Education

Healthcare professionals working with female athletes should be qualified and experienced in the detection, diagnosis and treatment of the female athlete triad and iron-deficiency anaemia.

Educational programmes for athletes and coaches focused on prevention of the female athlete triad and iron-deficiency anaemia are recommended to decrease the incidence of these health concerns, to maximise athletic performance and to ensure that female athletes enjoy the benefits of sport participation.

7. TECHNOLOGY

7.1 Community of practice/training

The internet represents an ideal platform for the establishment of a portal/community where medical and scientific experts can share information for the purpose of enhancing best clinical practice and advancing science related to PHE. It can also act as a forum for ongoing education and training of the medical, administrative and athlete participants.

7.2 Data collection

Medical/research community portal

The PHE research project may contain a Web Portal where the sports medicine and scientific community with an interest in PHE can access, review and comment on the latest information, results and progress of this PHE research project.

Data-collection tools

The questionnaire components of the PHE facilitate the standardisation of the PHE and permit analysis of the sensitivity and specificity of the questions asked. Where practical, the questionnaire components can be completed via the internet provided any such internet-based programmes conform to the recognised technology industry standards for network security and authentication, and that they are in compliance with the local guidelines and/or standards for the collection and storage of Personal Health Information. An internet-based version of the PHE Questionnaire would be a time- and cost-efficient incremental step in the evolution of the PHE, enabling the participation of athletes, medical professionals and administrators from jurisdictions with limited facilities and budgets. An internet-based questionnaire application provides an efficient means to enforce data-collection standards across multiple input points, therefore improving the accuracy of any research outcomes.

7.3 Data mining

Web-based data repositories present an ideal environment within which deidentified aggregate PHE data can be mined and analysed, thereby facilitating the ongoing

Box 1 Non-cardiac systems that should be considered in a Periodic Health Examination

- ▶ Pulmonary
- ▶ Haematological
- ▶ Allergies
- ▶ Infections and immunological
- ▶ Ear, nose and throat
- ▶ Dermatological
- ▶ Urological and genital
- ▶ Gastrointestinal
- ▶ Nervous system (neurological)
- ▶ Endocrine/metabolic
- ▶ Psychological/psychiatric

improvement of best practices related to the PHE. In all cases, the security and privacy of this personal health data are of the utmost importance.

Where software tools are employed to facilitate the input and or collection of athlete data, the following principles should be considered:

Data security and privacy

- ▶ Data processing should be in keeping with good faith efforts.
- ▶ Data processing should be proportional (only collect the data that is needed).
- ▶ Data should be processed only for the purposes indicated and agreed to by the athlete and or his/her legal representative.
- ▶ Data should be precise.
- ▶ Data should be protected against any form of unauthorised processing and provide full and complete audit trail of all transactions related to the Data.
- ▶ Data should be legitimate.
- ▶ Data should be transparent to the owner (the athlete maintains access).

- ▶ Furthermore, any organisation implementing PHE should adopt best practices with respect to human behaviour and the safeguarding of all personal medical data.

8. PHE FORM

A final objective was to provide a practical PHE Form that could be used by various groups and form a starting-point for further evaluation. Testing and standardisation in medicine are not possible if we do not begin somewhere. The first step in creating such a form was to collect existing forms, including those in widespread use. These included the FIFA Pre Competition Medical Assessment (PCMA), the Pre-Participation Physical Evaluation form,¹²⁰ the electronic Pre-Participation Evaluation,¹²¹ the National Hockey League Pre-Participation Medical Evaluation form, plus specialised forms including the American Heart Association recommendations,¹²² the Lausanne Recommendations,¹⁴ plus the items outlined in the text of this manuscript. The second step was to combine these into a master set of questions/items that was inclusive. This was circulated to the authors for review.

The third step will be to go through refinement in the future. This should be done on the basis of scientific evidence, which will come through evaluation with prospective data collection in a variety of sporting populations.

9. SCIENTIFIC ADVISORS

The IOC now has high-level scientific advisors who are capable of monitoring new developments in the field of PHE, and of advising the IOC in relation to the use and abuse of PHE. These advisors will help ensure that athletes and coaches receive the benefits of these developments in improving their ability to prevent

Box 2 Dietary Restraint Questions (EDE-Q) correlated with low bone mineral density in high school endurance runners¹¹⁹

1. Have you been consciously trying to restrict the amount of food you eat to influence your shape or weight?
2. Have you gone for long periods of time (8 h or more) without eating anything in order to influence your shape or weight?
3. Have you attempted to avoid eating any foods that you like in order to influence your shape or weight?
4. Have you attempted to follow definite rules regarding your eating in order to influence your shape or weight; for example, a calorie limit, a set amount of food, or rules about what or when you should eat?
5. Have you had a definite desire for your stomach to feel empty?

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injury, and to enhance therapy if needed. The IOC will follow this field and hold a new conference in 2011.

10. FUTURE DIRECTIONS

It is recommended that PHEs be set up and conducted as research projects. Presently, the decision to implement a compulsory PHE must be taken by the International Federations. It must be in compliance with ethical and legal requirements applicable to biomedical research involving human beings. Project findings should be shared and used by the medical and scientific community to further develop and improve best practices. In particular, such research should be conducted "in accordance with the recognised principles of research ethics, in particular the Helsinki Declaration adopted by the World Medical Association (Edinburgh, 2000), and the applicable laws" (Article 7.5 of the Olympic Movement Medical Code).

Governing sports bodies (National Olympic Committees and International Federations) are encouraged to support research activities to provide sport discipline specific scientific and medical evidence as related to the improvement and application of PHE.

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Consensus statement

APPENDIX A

Table A1 Periodic Health Examination Form

Physical examination		
Date of examination: _____	Normal	Abnormal (specify)
Medical		
Appearance		
Eyes/ears/nose/throat		
Hearing		
Lymph nodes		
Heart		
Rhythm		
Heart sounds/murmurs in supine and standing		
Peripheral oedema		
Physical stigmata of Marfan syndrome		
Blood vessels		
Peripheral pulses		
Delay in femoral pulses		
Vascular bruits (femoral)		
Varicose veins		
Blood pressure in sitting position (after 5 min rest)		
Right arm		
Left arm		
Heart rate (after 5 min rest)		
Lungs		
Abdomen		
Genitourinary (males only)		
Skin		
Eyes		
Visual acuity (corrected/uncorrected)		
Equal pupils		
Dental		
DMF index = number of decayed, missing or filled teeth: _____		
Oral hygiene assessment: <input type="checkbox"/> Good <input type="checkbox"/> Fair <input type="checkbox"/> Poor		
Visible oral infection: <input type="checkbox"/> No <input type="checkbox"/> Yes		
Presence of worn, broken or loose/mobile teeth: <input type="checkbox"/> No <input type="checkbox"/> Yes		
Dental appliances (bridge, plate, braces or orthodontic appliance): <input type="checkbox"/> No <input type="checkbox"/> Yes		
Musculoskeletal		
Neck		
Back		
Shoulder/arm		
Elbow/forearm		
Wrist/hand/fingers		
Hip/thigh		
Knee		
Leg/ankle		
Foot/toes		
Investigations		
12 Lead ECG		Details:
<input type="checkbox"/> Normal/no changes		
<input type="checkbox"/> Common and training-related ECG changes		
<input type="checkbox"/> Uncommon training-unrelated ECG changes		
Blood Tests		Other:
Haemoglobin		
Haematocrit		
Erythrocytes		
Thrombocytes		
Leukocytes		
Ferritin		
Sodium		
Potassium		
Creatinine		
Cholesterol (total)		
LDL cholesterol		
HDL cholesterol		

Continued

Table A1 Continued**Physical examination**

Triglycerides

Glucose

C-reactive protein

Clinical evaluation outcome

- 1 The athlete does not present apparent clinical contraindications to practice the following sport(s) (specify): No
Yes

If the answer to question 1 is "No", it is recommended that the athlete:

avoids participating:

▶ in training (explain) No Yes

▶ in competition (explain) No Yes

respects the following restrictions:

▶ during training (specify) No Yes

▶ during competition (specify) No Yes

undergoes further examinations (specify):

Examining physician

Name: _____ Phone number: _____

Address: _____ Email: _____

Signature of examiner: _____ Date: _____