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Andreas B. Imhoff
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The Sports Medicine Physician

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Editors
Sérgio Rocha Piedade
Orthopedics and Traumatology
State University
of Campinas – UNICAMP
Campinas / Sao Paulo
Brazil

Mark Clatworthy
Ascot Hospital
Auckland
New Zealand

João Espregueira-Mendes
Espregueira-Mendes Sports Centre
Clínica do Dragão
Porto
Portugal

Andreas B. Imhoff
Orthopaedic Sports Medicine
University of Munich (TUM)
München, Bayern
Germany

Moises Cohen
Department of Orthopedics &
Traumatology
Federal University of São Paulo
Vila Clementino - São Paulo
São Paulo
Brazil

ISBN 978-3-030-10432-0 ISBN 978-3-030-10433-7 (eBook)
https://doi.org/10.1007/978-3-030-10433-7

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Throughout our life, we are driven toward our dreams; we define paths and strategies and fight for them to become true; we are all moved by challenges. Since ancient times, strife, conquest, and defeat are part of human nature; and this explains why sports are so amazing to practice, watch, and support.

Sports offer us magic moments in which we vent our anxieties and disappointments, share dreams and emotions, and also learn to win and lose. Moreover, sports play a fundamental role in health and education, as they make us aware of the importance of healthy habits, teamwork, and respect for others.

Sports are not only related to recreational and professional competitions, but they are also a tool to reach a quality lifestyle. It strengthens the importance of sports medicine in the management of the effects of physical, recreational, or competitive activity on people. The broad spectrum of sports medicine area accounts to sports practice principles, overtraining injuries, neurological disorders, sports trauma, special clinical conditions, different scenarios in sports (indoor and winter), sports footwear, biologics in sports injuries, major events in sports, and PROMs in sports. Moreover, it allows us to navigate throughout all life phases: childhood, adolescence, adult life, and, the "most experienced of all," old age.

The Sports Medicine Physician book has involved professionals of sports medicine area and orthopedic surgeons from over 20 countries in the world. This book has 50 chapters organized in 10 parts covering different aspects and domains in sports medicine.

Like any huge project, there is a great Team involved. I would like to thank the ISAKOS President Mark Safran and Former President Philippe Neyret, ISAKOS Board, Andreas B. Imhoff, Mark Clatworthy, Moises Cohen, Joao Espregueira-Mendes, Mark R. Hutchinson, Committee members, and all health professionals that have accepted to work in this book, sharing their academic and clinical knowledge as well as experience in sports medicine. Thanks to all of you, my Team, Ge, Cezar, Mariana and Ana Karina Piedade, and Magda S. Kimoto, for supporting me in this amazing project.

Sports make us better, stronger, and true because, in sports, we learn the importance of teamwork.

Campinas, Sao Paulo, Brazil — Sérgio Rocha Piedade

Contents

Part I

Sports Practice Principles

1 Multidisciplinary Sport Medicine Team

Francesco Della Villa, Stefano Della Villa, and João Espregueira Mendes

1.1 Outline

The Sports Medicine care, either in a Sport team setting or in a Sports rehabilitation one, should be always based on a team effort. A patient- or athlete-centered approach, with different contributing professional figures, is warranted to maximize health and functional outcomes of our patients, either in primary prevention or rehabilitation setting. The central role of the caregiver team is highlighted in this first chapter in which we wish to present our experience in the basic principles of both playing in and managing a team around the patient in a Sports Medicine setting.

> A proper team, with a high performance culture is key for successful Sports Medicine practice.

1.2 The Crucial Principles

In building a Sport Medicine team, we'd like to share few important concepts at the beginning of this chapter: "No one professional nowadays can handle by his own the complexity of a sport rehabilitation path or injury prevention and training program." This concept is very easy and applies both to primary and secondary prevention of Sport injuries. If you play in team, your odds of winning (achieving good outcomes) are much higher. A proper team, with a high-performance culture, is warranted to carry on a successful Sport Medicine practice. With high-performance culture, we mean the ability to give your maximal effort in the day-by-day activity, helping the patient to reach the maximal possible functional recovery.

F. D. Villa (✉)
Education and Research Department, Isokinetic Medical Group—FIFA Medical Centre of Excellence, Bologna, Italy
e-mail: f.dellavilla@isokinetic.com

S. D. Villa
Educational and Research Department, Isokinetic Medical Group—FIFA Medical Centre of Excellence, Bologna, Italy
e-mail: s.dellavilla@isokinetic.com

J. E. Mendes
Clínica do Dragão—Espregueira-Mendes Sports Centre, FIFA Medical Centre of Excellence, FC Porto Stadium, Porto, Portugal

Orthopaedic Department, Minho University, Minho, Portugal

Publication Committee of the International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS), San Ramon, CA, USA

Patellofemoral Foundation, Farmington, CT, USA

FIFA MCE, Porto, Portugal

Porto University, Porto, Portugal

European Society of Sports Traumatology, Knee Surgery and Arthroscopy (ESSKA) 2012-2014, Bologna, Italy
e-mail: jem@espregueira.com

S. Rocha Piedade et al. (eds.), *The Sports Medicine Physician*,
https://doi.org/10.1007/978-3-030-10433-7_1

Fig. 1.1 Proper team. Sport Medicine physician, a physical therapist, and an athletic trainer. A patient-first approach is warranted as he/she needs to be guided in the recovery process

In our vision, considering Sport rehabilitation as a model of practice, you will need at least (1) *a Sport Medicine physician*, (2) *a physical therapist*, and (3) *an athletic trainer* to face a correct rehabilitation program (Fig. 1.1).

The Sports Medicine team should always adopt a patient-centered approach. The patient is the leading actor in every functional recovery path. The program must be tailored on his and her needs. Stated that, apart the professional figures listed above, the team can be larger. Chiropractors, specialists in nutrition, and sport psychologists can cover specific areas of functional recovery, optimizing specific areas of concern (Fig. 1.2).

Second point, you need to give the team the possibility to do a great job. Proper facilities are another important issue. If you wish to deliver an updated service, you will need also appropriate facilities to do this. For example, we strongly believe in different environments to give progressive stimuli during functional recovery, the use of *pools*, *gyms*, and *sports field* is key to optimize loading. The adoption of an on-field rehabilitation (OFR) setting is crucial to really complete the recovery path of a competitive athlete (Fig. 1.3).

Third and last general point, the team should follow an appropriate method. In our experience the method should be based on (1) a leader of the group, (2) an appropriate communication model, and (3) a proper and updated clinical method (Fig. 1.4).

First, besides shared decisionmaking, the team must be lead properly. The figure of the leader is always important and crucial in giving a precise tactical and strategic direction to the group, both in the day-by-day activity and in key decisionmaking. In organizing a rehabilitation service, we introduced the so-called concept of the *case manager*. The case manager is the doctor in charge of the patient, from the beginning to the end of functional recovery. He is also in charge of

Fig. 1.2 Patient-centered approach. A Sport Medicine physician talking with the physical therapist and the patient during a gym rehabilitation session. High-quality communication, also based on nonformal meeting, is key to control the recovery process

Fig. 1.3 Proper facilities. Different environments are crucial to customize treatments and allow a complete functional recovery

Fig. 1.4 Proper method. These three aspects are of paramount importance in the organization of teamwork

coordinating the team around the patient and communicating with patient environment. Such a figure is warranted in every recovery process.

A *continuous and effective communication* is warranted within the caregivers' team. Having a communication model (e.g., digital clinical records) and periodically (daily if necessary) meetings are the milestones of a well-organized service. Formal and informal communication is key to strengthen the relationship between the different players. The more you communicate within the team, the more you can maximize patient or athlete's perception of the recovery path and minimization of the risk of misleading information to the patient.

Adopting a proper and updated clinical method is the last aspect to be underlined. Statements like "I am doing like this because we have always done in this way" are no longer acceptable in the modern Sport Medicine landscape. Updated practice based on evidence-based recommendation has now to be imbedded in the practice. Considering again a rehabilitation perspective, we strongly believe in criteria-based, rather than time-based, rehabilitation protocols. In respect of the ACL-injured athletes, this statement is not based merely on a personal perspective but on the evidence that certain criteria should be met in order to RTP safely [1]. Current clinical guidelines are also recommending such an approach [2, 3]. Translating medical innovations inside this paradigm is not easy as new does not always mean effective. It is recommended to apply innovations that guarantee a reasonable optimization of functional outcomes, helping the patients and athletes to do better. For this reason, tracking patient's outcome is always wise to evaluate recent addictions.

1.3 We Are Doctors: Health and Performance Considerations

Another factor we need to consider is the existing relation between health, functional outcome, and performance. In the Sport Medicine scenario, our patients are athletes, and they need to perform, sometimes at elite level, at their best. Either working in a Sport team or in Sports rehabilitation facility, we need to prepare them to a sustainable performance. Winning in Sports is a key aspect, but, as doctors, we need to take care about the health of our athletes and patients, finding the correct balance for a sustainable (for the athlete) performance and short- and long-term outcomes. A good example of this concept is a possible existing relationship between the application of injury prevention and winning in football: the lower the injury rate, the higher the team success [4]. Another good example is the functional outcomes after anterior cruciate ligament reconstruction (ACLR). The patient faces two main outcomes; on one side there is the return to play at pre-injury level, and on the other side there is the second ACL injury risk. Again, we need to prepare the patient to perform again, minimizing the physical deficit related to the injury and surgery while reducing, as much as we can, the risk factors for the second injury. The goal of any sportsman or sportswoman is competing at their desired levels with a minimal risk of injury. The Sport Medicine team should help them to achieve this goal. When an injury happens, there should be a correct strategy to face it. As injuries are part of Sports, it is appropriate to speak about injury reduction strategies, as complete prevention is not possible.

1.4 The Case Manager Concept

In the first section of this chapter, we introduce the concept of the case manager. We would like to underline the importance of such a figure in the recovery process after Sport injuries. In the clinical practice, often, the patients see different professional's figures, in different places, potentially giving conflictual, sometimes opposite, suggestions. This is a common story that our patient faces every day. This situation is confusing and nonoptimal for the patient. To minimize the risk of this scenario, we introduced the concept of the case manager. The case manager (same Sport Medicine physician following the patient) oversees the patient through his or her whole recovery process. When surgery is needed, the case manager is in charge of cross talking with the surgeon and the surgical team. We really believe that surgery and rehabilitation are part of the same path; there is no stand-alone in this process (Fig. 1.5).

Fig. 1.5 The case manager. The physician should be the key figure for the patient. A reference point to guide the recovery process

Fig. 1.6 The injury to recovery process. Many steps and obstacles must be overcome to reach a successful RTP. As a community we have a very good control of the first phases, but we generally lack in control over the last steps. This deficit has to be solved

Either with conservative or surgical patients, there is a clear need of taking and maintaining a precise direction in every recovery path, and the patient will benefit from this approach.

We also believe that the same Sport Medicine team should follow the patient from the time of injury to the time of official return to play. The injury to recovery process is tough for the athlete, and we should have a perfect control of the whole path. Taking the example of a major injury (Fig. 1.6) requiring surgery, it is not enough to do half of the way to the top.

> The same Sport Medicine team should follow the patient from the time of injury to RTP.

Generally, we have a good control of the first steps (including diagnosis, surgery, and postoperative treatment). It is a pretty good con-

trol of the strengthening phase, but we lack in control of the last crucial phases, when the patient is generally left alone, in the grey area before returning to play. We need to focus also the last part of the recovery process. To reach this goal, we need to challenge our physicians' mind and change our point of view.

1.5 Changing the Status Quo: Return-to-Play Philosophy

To change the status quo, we need to challenge our vision of Sports injuries as doctors. As clinician our focus is on the lesion, on the injured site. We want to fix it as soon as we can. This is right, but we also need to focus the athlete's functioning at 360°, shifting the focus from the injured site to the athlete (Fig. 1.7).

Focusing the return to play from the very first day allows the team to establish a comprehensive (and not reductionistic) return-to-play strategy. Once focusing the RTP, we have the opportunity to highlight some crucial, and often overlooked, aspects especially focusing our focus on end-stage rehabilitation concepts:

- *Criteria-based return-to-play progression*
- *Movement patterns treatment and motor learning techniques*
- *On-field rehabilitation and optimization of the acute on chronic workload*

1.5.1 Criteria-Based Return-to-Play Progression

The common sense, supported by emerging evidence, is that rehabilitation after major knee injuries should be criteria based rather than time based [5, 6]. Criteria-based protocols have been suggested also for muscle injuries [7]. With this

Fig. 1.7 Shift the focus. Shifting the focus on athlete at 360° allows the team to consider other key factors in the rehabilitation process

kind of approach, certain criteria or pitfalls have to be reached in order to progress in the recovery process. In this way a comprehensive and really customized program may be carried out for every patient. This approach has been recently demonstrated to reduce the risk of second ACL injury after ACLR [1]. The same approach can be applied to every recovery process.

1.5.2 Movement Pattern Treatment and Motor Learning Techniques

The comprehension of biomechanical and neurophysiological factors is affecting deeply the way of considering the whole recovery process after lower limb injuries (Fig. 1.8). Clinical, user-friendly, qualitative movement analysis test has been proposed [8–10] and should be part, together with targeted neuromuscular training, of the return-to-sport process after lower limb injuries. On the other hand, feedback techniques have been developed to enhance motor learning, helping the patient to optimize his or her movement patterns [11].

Fig. 1.8 Risky movement patterns, with dynamic knee valgus loading, are frequently present at the time of return to play, especially in young patients

Although the greater amount of research on this aspect is related to RTP after ACLR, there is a growing body of evidence and common sense that the dynamic control of the entire kinetic chain is a key aspect also for other kinds of patients [12].

There needs to be an increased focus on biomechanical and movement pattern aspects after injuries. However, this consideration has to be coupled with an underlined importance of the previous and concomitant work on knee and hip strength. It is nonsense to work on complex movement patterns if the patient has not recovered isolated strength yet; for this reason a battery of tests, instead of a single-dimension assessment, is warranted.

1.5.3 On-Field Rehabilitation and Optimization of the Acute on Chronic Workload

The completion of a stepwise OFR program has been previously presented and correlated to successful outcomes after major knee injuries [13–15]. The OFR program is key to fill the gap between standard rehabilitation and return to play. As stated above, the patient is often left alone. This situation is potentially threatening all the previous efforts, as a nonoptimal management of the RTP phase may be dangerous. At this time, the patient generally starts loading more the injured joint. The key aspects of OFR are (1) *movement quality in high speed and unpredictable movements*, (2) *complete aerobic and anaerobic reconditioning*, (3) *optimal progression of patient workload*, and (4) *sport-specific gesture recovery.*

The transition between the rehabilitation environment and the training fields has to be as smooth as possible. Measuring workloads progressively, with real-time feedback, can help in targeting the desired amount of load.

End-stage functional recovery is as important as early stage rehabilitation.

The objective of this chapter is not covering technical aspects but instead giving an inspiration of some new area of potential clinical application in nowadays Sport Medicine.

1.6 Conclusions

Providing a Sport Medicine practice should be always based on a team effort. Proper facilities and proper logistic and clinical organizations are other important points not to be overlooked. A team of caregivers covering from the beginning to the end of the rehabilitation process is warranted in conjunction to an increased attention to the last part of the process. As Sport Medicine is a young and active branch of medicine, the Sport Medicine team should embrace new addictions in practice, always considering the clinical benefit for the patients.

References

1. Kyritsis P, Bahr R, Landreau P, Miladi R, Witvrouw E. Likelihood of ACL graft rupture: not meeting six clinical discharge criteria before return to sport is associated with a four times greater risk of rupture. Br J Sports Med. 2016;50(15):946–51. https://doi.org/10.1136/bjsports-2015-095908.
2. Davies GJ, McCarty E, Provencher M, Manske RC. ACL return to sport guidelines and criteria. Curr Rev Muscoskelet Med. 2017;10(3):307–14. https://doi.org/10.1007/s12178-017-9420-9.
3. Van Melick N, Van Cingel REH, Brooijmans F, Neeter C, Van Tienen T, Hullegie W, Der Sanden MWGN. Evidence-based clinical practice update: practice guidelines for anterior cruciate ligament rehabilitation based on a systematic review and multidisciplinary consensus. Br J Sports Med. 2016;50(24):1506–15. https://doi.org/10.1136/bjsports-2015-095898.
4. Eirale C, Tol JL, Farooq A, Smiley F, Chalabi H. Low injury rate strongly correlates with team success in Qatari professional football. Br J Sports Med. 2013;47(12):807–8. https://doi.org/10.1136/bjsports-2012-091040.
5. Adams D, Logerstedt D, Hunter-Giordano A, Axe MJ, Snyder-Mackler L. Current concepts for anterior cruciate ligament reconstruction: a criterion-based rehabilitation progression. J Orthop Sports Phys Ther. 2013;42(7):601–14. https://doi.org/10.2519/jospt.2012.3871.
6. Myer GD, Paterno MV, Ford KR, Quatman CE, Hewett TE. Rehabilitation after anterior cruciate ligament reconstruction: criteria-based progression through the return-to-sport phase. J Orthop Sports Phys Ther. 2006;36(6):385–402.
7. Heiderscheit BC, et al. Hamstring strain injuries: recommendations for diagnosis, rehabilitation, and injury prevention. J Orthop Sports Phys Ther. 2010;40(2):67–81.
8. Padua DA, DiStefano LJ, Beutler AI, De La Motte SJ, DiStefano MJ, Marshall SW. The landing error scoring system as a screening tool for an anterior cruciate ligament injury-prevention program in elite-youth soccer athletes. J Athl Train. 2015;50(6):589–95. https://doi.org/10.4085/1062-6050-50.1.10.
9. Garrison JC, Shanley E, Thigpen C, Geary R, Osler M, Delgiorno J. The reliability of the vail sport test™ as a measure of physical performance following anterior cruciate ligament reconstruction. Int J Sports Phys Ther. 2012;7(1):20–30.
10. Myer GD, Ford KR, Hewett TE. Tuck jump assessment for reducing anterior cruciate ligament injury risk. Athl Ther Today. 2008;13(5):39–44.
11. Benjaminse A, Gokeler A, Dowling AV, Faigenbaum A, Ford KR, Hewett TE, et al. Optimization of the anterior cruciate ligament injury prevention paradigm: novel feedback techniques to enhance motor learning and reduce injury risk. J Orthop Sports Phys Ther. 2015;45(3):170–82. https://doi.org/10.2519/jospt.2015.4986.
12. King E, Franklyn-Miller A, Richter C, O'Reilly E, Doolan M, Moran K, et al. Clinical and biomechanical outcomes of rehabilitation targeting intersegmental control in athletic groin pain: prospective cohort of 205 patients. Br J Sports Med. 2018. https://doi.org/10.1136/bjsports-2016-097089.
13. Della Villa S, Boldrini L, Ricci M, Danelon F, Snyder-Mackler L, Nanni G, Roi GS. Clinical outcomes and return-to-sports participation of 50 soccer players after anterior cruciate ligament reconstruction through a sport-specific rehabilitation protocol. Sports Health. 2012;4(1):17–24. https://doi.org/10.1177/1941738111417564.
14. Della Villa S, et al. Does intensive rehabilitation permit early return to sport without compromising the clinical outcome after arthroscopic autologous chondrocyte implantation in highly competitive athletes? Am J Sports Med. 2010;38(1):68–77.
15. Della Villa F, Ricci M, Perdisa F, Filardo G, Gamberini J, Caminati D, Della Villa S. Anterior cruciate ligament reconstruction and rehabilitation: predictors of functional outcome. Joints. 2016;3(4):179–85.

2 Pre-participation Evaluation in Sports Practice

Sérgio Rocha Piedade, Daniel Miranda Ferreira, Mario Ferreti Filho, Rodrigo Kallas Zogiab, Ivan Córcoles Martínez, Vitaliy Zayats, and Philippe Neyret

2.1 Background

Since ancient times, sports practice is well-recognized as a health-promoting activity as it has an effect act on our biological reserve, positively impacting the musculoskeletal, cardiovascular, and immunological systems, athletes' self-esteem and confidence, and improving their social integration [1–4]. This apart, participating in sports activities pushes people to compete and face challenges and also strengthens the desire to work as a team.

S. R. Piedade (✉) · R. K. Zogiab
Department of Orthopedics and Traumatology, State University of Campinas—UNICAMP, Exercise and Sports Medicine, Campinas, SP, Brazil
e-mail: piedade@fcm.unicamp.br

D. M. Ferreira
Department of Radiology, State University of Campinas—UNICAMP, Exercise and Sports Medicine, Campinas, SP, Brazil

M. F. Filho
Department of Orthopedics and Traumatology, UNIFESP, Sao Paulo, Brazil

I. C. Martínez
Hospital Universitario Joan XXII de Tarragona, Cataluña, Spain

V. Zayats
Trauma and Orthopedic Department, Pavlov First St. Petersburg State Medical University, Petersburg, Russia

P. Neyret
University Lyon 1, Lyon, France

However, sports practice is not an injury-free activity because it involves aspects of the modality of practiced sports, athletes' biological, and physical conditions. The intensity of physical demands is particular to each sports modality, varying according to its dynamic (soccer, basketball, volleyball, tennis, cricket, MMA, judo, surf), field, and environmental conditions where the sport is practised (indoor, outdoor) [5–8]. Within this context, the rules of the sport should be adjusted and improved whenever necessary such as the implementation of protective measures (helmets, mouth guards, gloves), time of the dispute, and rest intervals during the games, resulting in fairer dispute and contributing to decreasing the athlete's exposure to injuries [9–13].

However, the athletes' clinical and physical conditions are influenced by their age, gender, presence of chronic diseases (diabetes, hypertension, heart disease), overweight, previous injuries, neurological disorders, psychological distress, and handicaps. All these conditions do not necessarily preclude sports practice, but they must be identified and appropriately treated to define the best approach before starting sports practice and allowing the athlete to perform his/her activities within a safe zone, minimizing exposure to clinical adverse effects [14–17].

Unfortunately, sudden cardiac arrest, one of the most overwhelming events in sports practice, could signal the first clinical presentation of an underlying cardiovascular disease. Without a

S. Rocha Piedade et al. (eds.), *The Sports Medicine Physician*,
https://doi.org/10.1007/978-3-030-10433-7_2

doubt, this dramatic and stressful clinical event could happen in a sports physician's practice and may cause traumatic effects to the sports community (athletes, coaches, fitness instructors, and sports fans) as it could touch young individuals in the prime of their lives [18–25].

In this context, pre-participation evaluation (PPE) is considered the cornerstone of sports injury prevention as it plays a vital role to assess athlete's overall health, recognizing health problems, and defining medical strategies and recommendations to achieve and maintain the athletes' "wellness" [26–28]. The PPE main goals are to previously identify:

- Clinical conditions that may be life-threating and impose relative or formal contraindication to sports practice
- Prior injuries that can be treated and appropriately rehabilitated before starting sports activities
- Clinical comorbidities and handicaps that predispose to illness and injury, recognizing high-risk individuals for sports practice
- Also, to assess fitness for a specific sport

Although PPE presents a valuable tool to monitor the athletes' health during their lifetime in sports, offering numerous benefits to their health care, this approach is not well-standardized worldwide. An example of that is seen in Europe, where PPE rules and strategies are not similar among the countries [29]. In France, a general clinical assessment is well-accepted such as PPE for amateur athletes, but, for competitive athletes, a more rigorous health control to certify the absence of contraindications to sports practice is required. For more than 35 years, the Italian government has regulated and established PPE as mandatory for competitive athletes, while, in the Netherlands, citizens are regularly evaluated [29].

According to the modality of sports, PPE should pay particular attention to clinical aspects which are commonly associated with specific sports injuries**. In contact sports** such as rugby, martial arts, football, and ice hockey, the spine is exposed to high-energy trauma that potentializes the occurrence of **concussion, facial trauma, spinal cord injury due to the dynamics of these sports** [30–32]. Transient quadriplegia is a sports injury commonly seen in American football and contact sports. This injury results from axial trauma with flexion/extension of the athlete's head with underlying cervical spinal canal stenosis, a structural disorder that should be investigated and ruled out in these athletes during PPE.

In athletes of wilderness watersports, one of the concerns is that the athlete's breath holding and buoyancy capacities are limited to their physical status that decreases when exposed to cold water condition due to muscle overload in an attempt to control body temperature and avoid the occurrence of hypothermia [33]. In these athletes, PPE can focus on assessing acute and chronic clinical conditions that could impair the athlete's ability to swim.

In endurance sports, In endurance sports, weight-classified sports and aesthetic sports, there is a close relationship with pathogenic weight control behaviors, clinically manifested by disordered eating, the decrease of bone mass density, and menstrual dysfunction in females. As this pathological condition impacts negatively on athletes' performance, the PPE should take it into account [33, 34]. Therefore, all these points reinforce the importance of PPE to athletes' health care.

This chapter **presents** and discusses elements involved in PPE and particularities related to different athletes' population according to their gender, age (childhood and adolescence, adulthood and old age), and level of sports practice (recreational, disabled, and professional athletes).

2.2 Pre-participation Evaluation

A well-structured PPE should be based on athletes' medical and sports injury history and their family's medical history. It is considered the first step to screen and identify possible cardiovascular injuries related to sudden death. This strategy is a useful tool to map populations of athletes and tailor PPE regardless of their age, gender, modality of sports, and level of sports practice. In general, PPE has the same structure and design for every athlete, but it should be tailored

for each athlete according to their age, gender, clinical condition, handicap, as well as the level of sports practice (recreational, amateur, and professional) reported.

2.3 Periodization of PPE

In clinical practice, it is recommended that PPE be applied 6–8 weeks before starting sports practice because it allows enough time to rehabilitate injuries, identify, and manage any medical disorders properly, minimizing the risk of exposing athletes to injury.

PPE applied to athletes, recreational or professional, before starting a new program of sports practice is advisable, an important step to minimize the athlete's exposure to adverse clinical events such as a sudden cardiac arrest. Although, PPE is a dynamic issue, its advancements involve costs which should be justified by the cost-benefit. It presents excellent sensitivity, specificity, and effectiveness in reducing adverse effects and mortality [33–36]. However, its implementation also depends on national/regional settings to achieve the most accurate physical examination.

As discussed above, PPE may contribute to injury prevention and evaluation of prior clinical conditions that may predispose the athlete to illness or injuries as well as to the identification of conditions that do not present overt symptoms, reinforcing PPE periodization. In clinical practice, the sports physician's decision-making takes into consideration the questions listed below:

- Is there a formal risk to the athlete?
- Can the athlete:
  - Under medical treatment compete safely?
  - Participate in another sports activity?
  - Be cleared for certain sports?
- Could this problem affect other athletes?

PPE involves anamnesis, an athlete's general health history and sports injuries report and also the family health history [33–36]. These data are useful as they guide the physical assessment as well as laboratory and radiological exams needed to evaluate the athlete's physical health properly and, at the same time, rule out adverse clinical conditions to sports practice.

2.4 Anamnesis

The PPE anamnesis has a three-key point structure namely: the athlete's general health, sports injuries, and family health history. All these elements are a sensitive tool to analyze the athlete's health status and screen for potential clinical problems or deficits that can impair the athlete's performance or expose him/her to injury or illness. Moreover, it is helpful to carry out the physical assessment according to the reported data. Before starting PPE application, the sports medicine physician should try to offer a comfortable environment so that the athletes feel more confident to reply to questions. The physician should start talking and asking the athletes informally about their motivation to sports practice, sports/quality of life, and health concerns:

- How motivated are you to play sports?
- Do you feel in good shape to practise sports?
- Have you been sleeping well?
- Do you have any concerns about healthy eating?
- Do you have any complaints when playing sports?

2.4.1 Athlete's General Health History

It comprises of the data of complaints or clinical problems related to body systems, psychological status, exertional symptoms, dietary, oral health, social behavior, infectious diseases, hospitalizations, and surgical procedures. A point to be reinforced is the role of oral health assessment in monitoring nutritional deficiency and also systematic diseases that could affect athletes' performance. Table 2.1 summarizes some of the relevant points.

Table 2.1 Points to be assessed during an athlete's general health exam

Skin Dermatitis, allergies (triggered by food, insects, medicines), infections (bacteria, virus), acne (wrestlers)
Psychological distress or disorders Anxiety, depression, OCD, eating disorders, anorexia, REDS
Oral Gingivitis, tooth loss, tooth pain, herpex simplex
Gastrointestinal disorders Gastritis, hepatitis, abdominal tenderness or masses
Neurological Mental status, suspicious of sports-related concussion, confusion or memory loss after a head trauma
Cardiovascular Palpitations or irregular heartbeat, exertional chest pain, syncope, shortness of breath, and fatigue on exertion
Urinary Calculus, infections, nephritis, kidney agenesis
Respiratory Chronic respiratory problems (asthma, bk) or acute (infections, pneumonia), exercise-induced bronchospasm
Musculoskeletal Arthrosis, ligament injury, fracture, muscle injury, sprain, patellofemoral dislocation, hernia, rheumatologic diseases, miopathy
Medication for chronic diseases Beta blocker, diuretic, antidepressive, steroids, anti-inflammatory drugs
Prior surgeries Fracture, ligament reconstruction, arthrodesis, heart revascularization
Endocrinological Diabetes, hyperparathyroidism, hypercholesterolemia
Hospitalization/previous surgeries Fracture, ligament reconstruction, arthrodesis, heart heart revascularization, prothesis
Special clinical signs in females Menstrual dysfunction, amenorrhea or oligomenorrhea, osteoporosis (young female)

2.4.2 Athlete's Sports Injury and Clinical Complaints Related to Sports Practice

Recording the athlete's prior injuries, their surgical and rehabilitation treatments after sports trauma, and the reports on the regular use of protective equipment in sports practice allows a better understanding of athlete's health status and physical condition. In this context, sprains, fractures, ligament injuries, hernia, cervical and head trauma, chest pain, fatigue, and difficulty breathing during high-intensity exercises should be carefully investigated by the sports physician [37].

2.4.3 Family Medical History

Considering that people from the same family have many aspects in common such as genetics, environment, and life style, the athlete's family medical history has a vital role in PPE. It allows tracking health information about the athlete's close relatives and helps to identify chronic diseases that could impact the athlete's health when practicing sports like a cardiovascular diseases such as cardiovascular disease (hypertension, myocardiopathy), diabetes, asthma and exercise-induced bronchospasm, gastrointestinal disorders, hematological disorders, neurological diseases, eating disorders, psychiatric disorders and, cancer that could impact the athlete's health when practising sports.

2.5 Musculoskeletal Screening

A physical examination plays an essential role on the PPE process. It allows the screening and evaluation of muscle and joint function regarding balance and motion range symmetry as well as the level of muscle force between limbs [37–39]. Moreover, a physical examination can reveal clues and identify previous or even unknown injuries besides muscle weakness, stretching deficit, uni- or bilateral joint motion restriction, limb discrepancy or malalignment, collagene disease (such as Marfan from low expression (hiperlaxity) to server) which could present clinical disorders that will expose the athlete to injuries.

2.6 Starting the Physical Examination

2.6.1 Inspection

The athlete is asked to wear underwear and no shirt for a GENERAL view of their body. Starting with the athlete's gait, the sports physician seeks to identify any changes in gait such as limping. Then, with the athlete in standing position, the skin is screened for lesions and scars and also if the spine is aligned.

2.6.2 Oral Health Assessment

The athlete is requested to open their mouth by placing two folded fingers (index and middle) at the distal interphalangeal joints of the mouth which allows the physician to check any restricted motion of TMDs (temporomandibular disorders). Besides that, the oral health status is checked regarding the status and color of the lips, mucosas, and teeth conditions (integrity, biofilm stagnation (bacterial plaque), the presence of calculus (tartar), dental loss, and also tooth wear (indirect signs of anxiety, depression, or stress that could commonly be associated with bruxism). **The oral health exam is vital to assess** the athletes' oral hygiene and its maintenance (periodical exams) as well as to identify clues of systemic diseases that impact the athletes' performance.

2.6.3 Dynamic Physical Evaluation

It should be emphasized that the physical examination is guided by the anamnesis (athletes' general health history, athletes' sports injuries and clinical complaints related to sports practice, and also their family medical history). In clinical practice, the physical exam starts with the spine motion and then goes on to upper limbs and finishes with lower limbs; the most common clinical tests performed in this evaluation are presented in Fig. 2.1. However, it should be emphasized that the **physical** assessment is carried out according to the reported data in the anamnesis (athlete's general health history, sports injuries, clinical complaints related to sports practice, and also their family medical history).

2.7 Regarding PPE in Different Age Groups

2.7.1 In Childhood and Adolescence

In many countries and regions due to the economic conditions, sports participation is a huge opportunity for children and adolescents to change their lives and also have access to health. Thus, PPE plays an essential role in it. Sports practice during childhood and adolescence is considered an important factor associated with health in adulthood and old age, and, therefore, it is vital to public health actions [40–42]. Consequently, millions of children and adolescents are involved in organized sports worldwide every year. However, it should be taken into account that this population involves individuals that are developing their biological patterns as well as social behaviors that will manifest during the rest of their lives. It should be kept in mind that the bone and joint maturation is a high energy process that involves biomechanical changes of the living tissues. In childhood, a bone is defined as an immature structure which is weaker (less mineralized) and ductile, while during adolescence it starts becoming more mineralized, conferring a stiff and brittle characteristic to it, until bone maturation takes places (Fig. 2.2). In this context, individuals younger than 18 years old should be followed closely due to the huge and rapid body changes occurring in childhood and adolescence. Therefore, childhood involves biological and clinical patterns that make these athletes different from adult athletes, and, therefore, children cannot be considered as "small adults".

In children and adolescents starting regular physical exercises and sports practice, PPE is helpful to screen unfavorable athletes' clinical conditions to some modalities of sports. For instance, in contact sports, the athletes are submitted to high-energy trauma as well as physical demands (Fig. 2.3).

An example of that is a young patient with a medical health history of rhinitis or recurrent sinusitis willing to practice swimming. This condition does not necessarily exclude its practice but allows the sports physician to identify the problem previously and treat the athlete adequately before letting him practise water sports.

Regarding the psychological aspects, a young athlete can became stressed due to training, competiting, and also their parents' unconscious behavior of projecting their own personal desire to be champion on their sons and daughters. All these aspects may impact a young athlete's social behavior, and, therefore, alcohol, smoking, and also drug addiction should be carefully investigated. Thus, it is recommended that the athlete's parents or guardian be present at PPE to confirm

Fig. 2.1 Dynamic physical evaluation

and add details of the athlete and family medical history [27–29].

As stated before, the periodicity of PPE is essential as it can identify the initial stages of energy deficiency in sports (REDs), a clinical problem that affects both men and women and involves low energy availability (involving eating disorders or not), low bone mineral density, and menstrual dysfunction and, therefore, should be carefully investigated [43, 44].

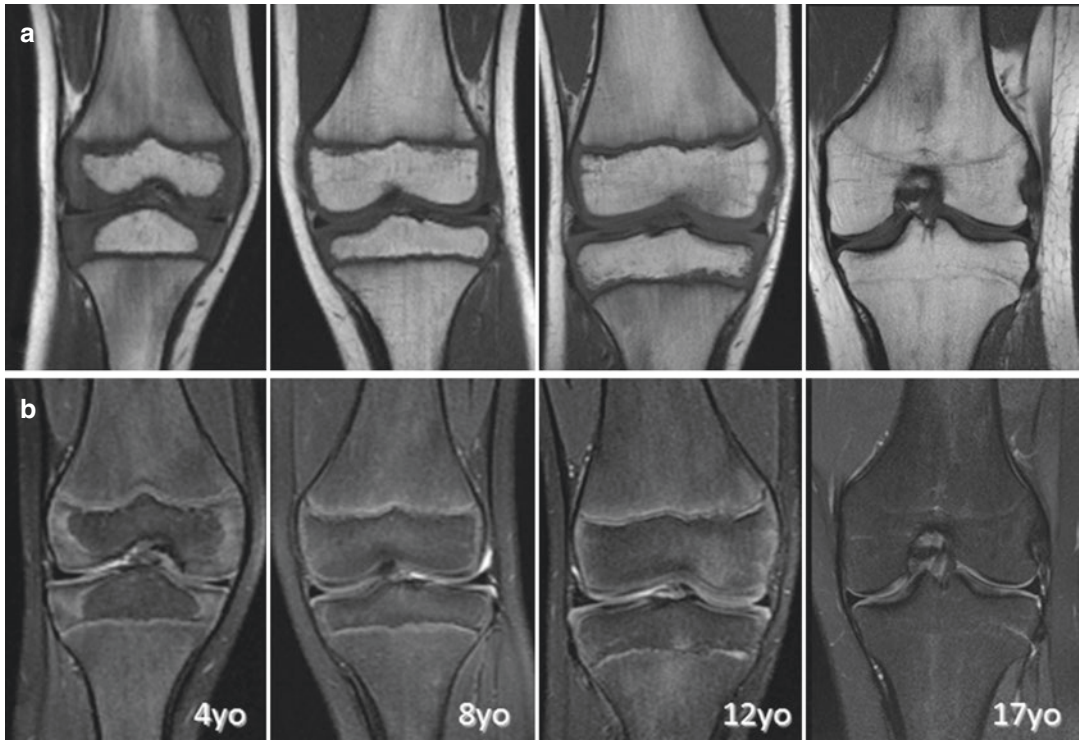

Fig. 2.2 Coronal T1 (**a**) and T2 fat sat (**b**) weighted of normal MRI views of the knee in young patients aged 4, 8, 12, and 17 years old

Fig. 2.3 Female rugby athletes

In general, the physical assessment in child and adolescent athletes focuses on the symmetry of lower-and-upper-limb joint movement strength, according to the modality of sports and its physical demands on the joints and muscles. In child and adolescent athletes, laboratory tests and radiological evaluation are requested, depending on the specific clinical disorder reported during the anamnesis or suspected in the physical assessment.

2.7.2 Adulthood and Old Age

Data from the World Health Organization has shown an increase in life expectancy in recent decades. In 2016 the average life expectancy at birth was 72 years. The global average life expectancy increased by 5.5 years between 2000 and 2016, the fastest increase since the 1960s [45]. Adulthood and old age are periods of life in which degenerative and chronic diseases begin to manifest (Fig. 2.4). Figure 2.3 compares the radiological patterns of a normal knee joint to a medial degenerative one.

According to a person's social habits, obesity, hypertension, diabetes, hypercholesterolemia, arthrosis, and cardiovascular diseases will take place. With the increasing ageing of the population, many people have begun to take up physical activity on a voluntary basis for a better quality of life and health benefits in the treatment and prevention of various diseases [46–50].

The population aged 35 years and older, so-called "masters" athletes, represents a challenge for health-care providers who are asked to make decisions regarding assessments of cardiovascular risk associated with different types of physical activity. Currently, there are no validated tools to help physicians assess the risk of physical activity in master athletes because most tools are geared towards screening younger participants [51]. Ageing athletes are exposed to exercise-induced cardiovascular events related to undiagnosed coronary artery disease, which is the primary cause of sudden cardiac death in masters' athletes [52].

The American Heart Association (AHA) and the American College of Sports Medicine (ACSM) developed the American Heart Association/American College of Sports Medicine Pre-participation Questionnaire (AAPQ) to enable cost-effective screening for cardiovascular risk among individuals who desire to initiate a fitness program [53]. If a subject responds positively to any of the statements regarding cardiac history or symptoms, or to two or more of the statements regarding risk factors, a recommendation is made for a pre-participation evaluation.

The 2001 Masters Athletics Working Group developed pre-participation guidelines for those who desire to participate in more competitive sporting events [54]:

- Stress test for men aged >40 years and women aged >50 years who also have one of the following conditions: hypercholesterolemia, systemic hypertension, current or recent cigarette smoking, diabetes mellitus, or history of myocardial infarction or sudden cardiac death in a first-degree relative aged <60 years
- Stress testing for all athletes aged ≥65 years
- Electrocardiogram (ECG) for all athletes male and female aged >40 years

Self-administered surveys such as the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) [55], the European Association of Cardiovascular Prevention and Rehabilitation (EACPR) recommendations [56], and the Framingham Risk Score (FRS) can be used in pre-participation screening of masters athletes [57].

Although some imaging tests that have sensitivity approaching close to 100% would be ideal to ascertain the prevalence of cardiovascular disease (Fig. 2.5), they are not performed routinely in PPE. The main reasons are that the current evidence for incorporating cardiac imaging into pre-participation screening is insufficient, expensive, potentially radioactive, and not indicated for testing generally healthy asymptomatic low-risk patients [58].

The optimal method to screen masters athletes requires continued study to decrease the number of false-positive with available and cost-effective screening tools to identify potentially at-risk individuals.

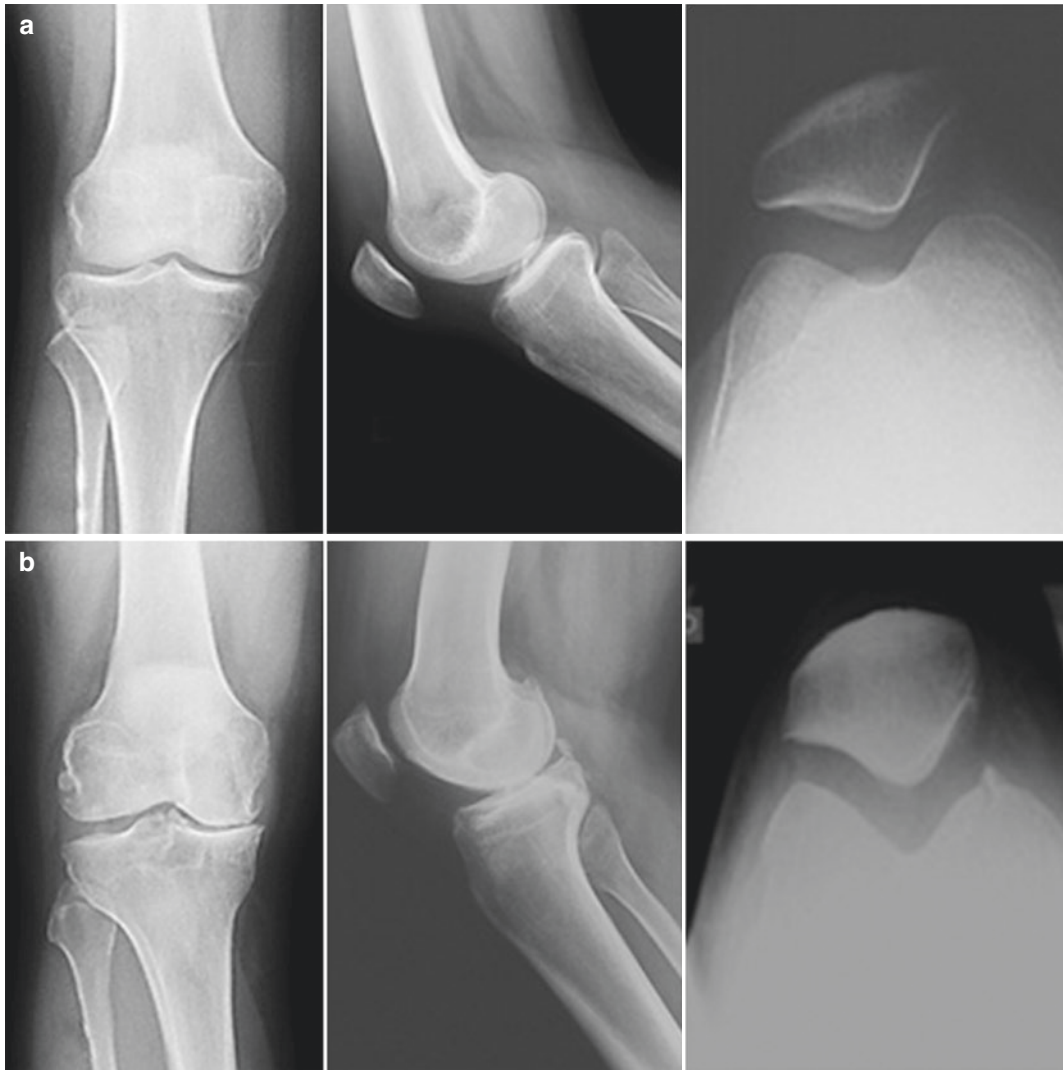

Fig. 2.4 Anteroposterior, lateral, and axial X-ray views of the knee (**a**) in the healthy knee of a 20-year-old patient. (**b**) Osteodegenerative changes (narrow of medial articular space, subchondral sclerosis, and femorotibial and femoropatellar osteophytes) in a 65-year-old patient

2.7.3 Disabled Athletes

Disabled athletes are a particular group of individuals that have functional impairment that could vary according to its cause. Considering that sports practice requires significant physical demands, disabled athletes should be subcategorized and also classified according to the type of physical handicap [59]. This allows the classification of athletes according to their functional impairment, establishes fair competition, and also minimizes the risk of athletes' injury in sports practice and competition events. In this context, the main reasons for functional impairment are summarized in Table 2.2.

In clinical practice, the ten most common physical impairments reported in disabled athletes are listed in Table 2.3. They serve as one of the parameters adopted to classify the athletes' functional level. However, it should be emphasized that the disabled athletes' classification remains a dynamic process. Each year, the technological advancement in the sports medicine

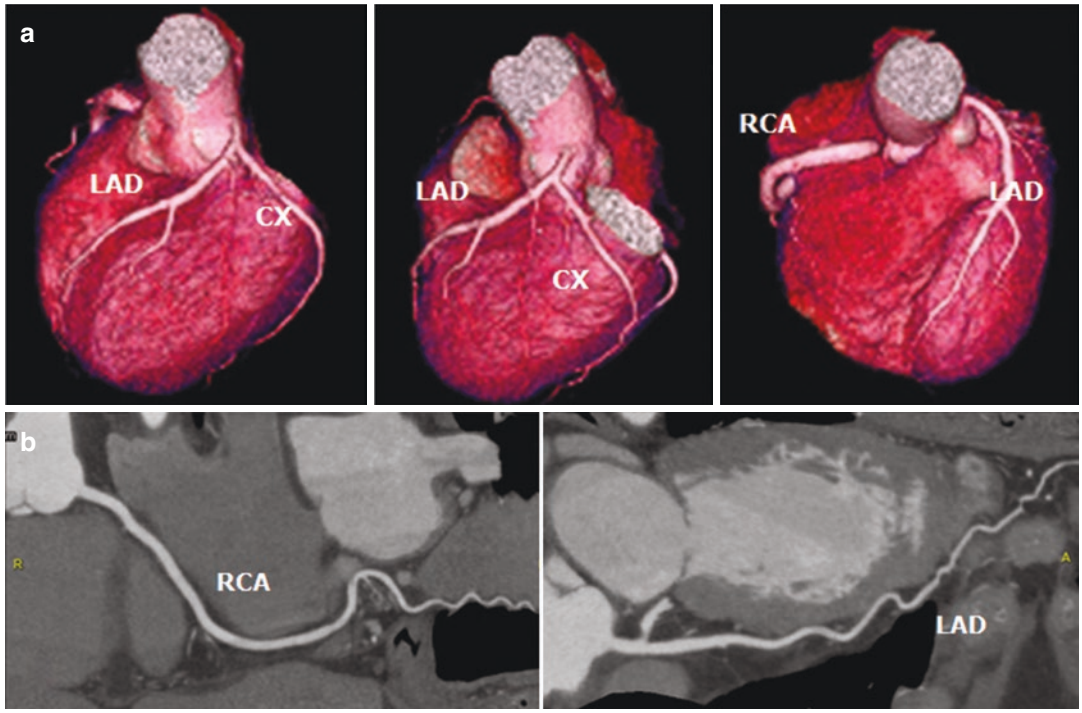

Fig. 2.5 Normal CT coronary angiography with no atheromatous plaques (**a**). Three-dimensional volume rendering technique and (**b**) maximum intensity projection technique. *RCA* right coronary artery, *LAD* left anterior descending, and *CX* circumflex artery

Table 2.2 Main reasons for functional impairment in disabled athletes

Spinal cord injury	Amputations
Cerebral palsy	Collagenosis
Muscular dystrophy	Limb malformation
Myelomeningocele	Acquired injuries due to traumas
Poliomyelitis	Blindness and low vision

Table 2.3 Most common physical impairments reported in clinical practice

Severely affected muscle power	Hypertonia
Impaired passive range of motion	Ataxia
Total or partial limb loss	Athetosis
Limb length discrepancy	Visual impairment
Short	Intellectual impairment

[a]Athletes with intellectual disability as well as youngsters with learning disabilities should be more explicitly instructed before starting regular sports practice

area has caused improvements in medical evaluation and diagnosis and consequently has promoted update on disabled athletes' functional classification for the Paralympics [60].

2.7.4 Elite Athletes

In general, in professional sports, the modality of sports and its dynamic (contact and noncontact sports) involve different physical demands. In this context, PPE focus should take into account the athlete's position in the field and its inherent risk, psychological and physical maturity, as well level of competition.

Elite athletes work under an elevated level of physical and psychological stress due to their level of competition, financial interests, and injuries. Therefore, in high-performance athletes of long running, cycling, endurance sports, football, basketball, volleyball, and MMA, PPE should involve a careful cardiological screening with a specialist, including an electrocardiogram at rest, laboratory tests for levels of glycemia, and cholesterol and triglyceride levels. The heart structure and function adapted to physical activity are screened by a Doppler echocardiogram, while an ergometric and cardiopulmonary test should be performed until exhaustion or stopped if the athlete presents adverse clinical signs or symptoms during the exam.