Advancing the Preparticipation Physical Evaluation (PPE): An ACSM and FIMS Joint Consensus Statement

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Abstract
While the preparticipation physical evaluation (PPE) is widely accepted, its usage and content are not standardized. Implementation is affected by cost, access, level of participation, participant age/sex, and local/regional/national mandate. PPE screening costs are generally borne by the athlete, family, or club. Screening involves generally agreed-upon questions based on expert opinion and tested over decades of use. No large-scale prospective controlled tracking programs have examined PPE outcomes. While the panel did not reach consensus on electrocardiogram screening as a routine part of PPE, all agreed that a history and physical exam focusing on cardiac risk is essential, and an ECG should be used where risk is increased. The many areas of consensus should help the American College of Sports Medicine and the Fédération Internationale du Médecine du Sport in developing a universally accepted PPE. An electronic PPE, using human-centered design, would be comprehensive, would provide a database given that PPE is mandatory in many locations, would simplify PPE administration, would allow remote access to clinical data, and would provide the much-needed data for prospective studies in this area.

Introduction
Different standards exist worldwide regarding the administration, content, format, and delivery of the preparticipation physical evaluation (PPE) for sports. In addition, there are multiple factors that determine implementation context including cost, access, level of participation (e.g., professional, leisure), age, and sex of the participant. In June 2013, a joint consensus meeting was held in Indianapolis, Indiana to explore the issue of potentially standardizing a PPE for sports. The meeting was convened by the American College of Sports Medicine (ACSM) and the Fédération Internationale du Médecine du Sport (FIMS), with members participating from both groups. While considering the primary international differences in conduct and content of the PPE, the group focused on the international commonalities and differences among approaches to the evaluation and screening of athletes; the assumptions and realities that have led to major differences in cardiovascular screening protocols like government or legislative requirements, cost, insurance coverage, equipment and personnel availability, sports health compared to public health aims, and population differences; the gaps and opportunities for progress in scientific

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The PPE Worldwide

The PPE is intended to identify conditions that may interfere with sports performance or limit high-level dynamic and/or static activity.

The goals of the PPE include:

1) Safe participation of elite athletes and leisure time athletes from children and adolescents up through the senior years;
2) Identification of medical problems with possible life-threatening complications due to inherited or acquired conditions (1).

While the PPE is largely accepted worldwide, its usage and content are not standardized. Most countries have no government-regulated PPE requirements. When a PPE is administered, it is because of participation requirements of a sport governing body, a recommendation of a medical organization, and/or legislated government requirements for a “sport license.” None of the requirements are age specific beyond the broad range of young athletes, generally defined as less than 35 years old. Looking at the outcomes of the evaluation in narrower age bands may improve the utility of the PPE (Table 1). A majority of the government-mandated programs, especially in Europe, are aimed at “elite” athletes and few address the lower level or non-elite participants in clubs, community, scholastic, and non-scholastic sport programs (2). For example, in Germany, a PPE including an ECG is recommended for all leisure time athletes and competitive athletes at the lower levels of play; however, all elite athletes are examined with history and physical exam, ECG, exercise testing, and cardiac echocardiography (3). In contrast, Italy and Israel have required examinations that include ECGs for all athletes in the range of 12- to 35-years-old, and Japan requires ECG screening for all children in school grades 1, 7, and 10, including athletes (2). Athletes are screened using generally agreed-upon question sets, based primarily on expert opinion (1). These question sets have been tested across several decades of use. However, few question sets have been developed or refined by a scientific method.

**Economic Considerations**

The costs of PPE screening are generally borne by the athlete, family, or club and are rarely covered by the government or commercial-sponsored health plans; therefore, self-pay is common in Europe and the U.S. (2). However, insurance companies in Germany now pay 70% of the exam cost including an ECG (change as of 2013). In addition, medical providers in the U.S. often donate time to deliver PPEs, and many U.S. child and adolescent athletes have their exams combined with insurance-covered well child exams. In countries where the PPE is legislated, the conduct of sports exams, especially elite athlete exams, is often limited to specific certified sports physicians (2).

In addition to understanding the medical issues associated with PPEs, it is important to consider the economic consequences of possible alternative screening strategies. A brief overview of cost effectiveness in health care provides the background for consideration of the economic perspective on the subject. Cost per quality-adjusted life year (QALY) is frequently used as a measure of cost effectiveness. Costs should be broadly defined to include costs to society. The analysis also should include indirect, as well as direct, costs. An important benefit of the QALY concept, as compared to simply life years or lives saved, is that it allows for both quality and quantity dimensions. A cost-effectiveness analysis involves stringent data demands, necessitating a large data-gathering exercise. First a researcher must outline a complete flowchart of possible scenarios associated with the intervention under consideration. Second, a cost must be estimated for each node of this flowchart. Multiple data sources are necessary to complete the analysis. The researcher will need to calculate QALYs based on the literature regarding outcomes and associated health-related quality of life for both the intervention under consideration and an alternative (either the status quo or another intervention). Such an exercise produces a measure of cost effectiveness that can be compared across multiple alternatives for many different types of interventions, which can facilitate the efficient allocation of resources for the potential health interventions.

**Screening Strategies**

Athlete screening strategies around the world vary widely, and some athletes are never screened with a PPE. The structure of a PPE may include: 1) history (Hx) (with or without a structured questionnaire) and physical exam (PE) with case finding studies as indicated; 2) Hx, PE, and screening ECG; 3) Hx, PE, ECG, and stress ECG; or 4) Hx, PE, ECG, and other (exercise ECG, echocardiogram, blood studies such as hemoglobin or iron, urinalysis, spirometry, chest x-ray, neuropsychological testing, and balance testing). Based on surveys and available literature, exam intervals vary from every six months to every three years and required ECG intervals vary from every year to every five years, with one country simply requiring ECGs at ages 15, 22, and 30 (2).

To date, no large scale prospective controlled tracking programs have examined outcomes of the PPE with respect

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**Table 1.**

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Age Range (Years)</th>
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<tbody>
<tr>
<td>Child</td>
<td>5–11</td>
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<tr>
<td>Adolescent Early</td>
<td>12–14</td>
</tr>
<tr>
<td>Adolescent High School*</td>
<td>15–18</td>
</tr>
<tr>
<td>College*</td>
<td>19–22</td>
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<tr>
<td>Young Adult</td>
<td>23–35</td>
</tr>
<tr>
<td>Middle Age Adult</td>
<td>35–65</td>
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<tr>
<td>Aging Adult</td>
<td>&gt;65</td>
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to injury prevention, sudden cardiac death (SCD) reduction, or other consequences of exercise and competition. The PPE is more than a “heart” exam, and there are other reasons to perform the task, including its potential use as a tool to reduce sport injury risk, counsel for high-risk behaviors, screen for chronic disease including depression, and place an athlete face-to-face with a physician or other health care provider.

Controversy Surrounding ECG Screening

While the panel did not reach consensus on the use of ECG screening as a routine part of the PPE, all agreed that a history and physical exam focusing on cardiac risk is essential, and an ECG should be used whenever potential increased risk is detected in the course of the examination. Below we lay out some of the main arguments on each side of the debate.

Arguments for Universal ECG Screening for Athletes

The European perspective of ECG screening has been influenced by the reported reduction in SCD in Italian athletes following a legislative mandate for PPEs with ECGs in the early 1980s. The history and physical examination are essential parts of PPE, but in Italy they are not considered sufficient without an ECG to reduce sudden cardiac events in athletes. The PPE in several European countries includes an ECG at rest, especially at elite levels of competition. This strategy is based on the combined experiences of the Italian ECG screening program and has been endorsed by many European sports medicine federations, the International Olympic Committee (IOC), and the Fédération Internationale de Football Association (FIFA).

The perceived strength of the Italian PPE for competitive athletes consists of the following:

1) It is mandated by law
2) It includes a 12-lead ECG both at rest and after a submaximal, 3-minute exercise step test
3) It is only performed by fully certified Sports Medicine Physicians

The Italian experience has demonstrated that the universal use of a 12-lead ECG can be accomplished, and the process has been deemed cost-effective for the athlete population in Italy. ECG was shown to have a high negative predictive value: A normal ECG is associated with a structurally normal heart in 95% of the cases (4). ECG abnormalities are commonly found in patients affected by potentially lethal cardiac disease, with the exception of those with congenital coronary anomalies (5). Unfortunately, the ECG is not infallible. A high prevalence of ECG abnormalities have been described in trained athletes. However, most of these ECGs were determined to be “false positive,” and only 14 of the 145 athletes with a distinctly abnormal ECG (10%) showed echocardiographic evidence of structural cardiac disease or abnormality. Collectively, the results of this study demonstrated poor sensitivity and specificity (51% and 61% respectively) of abnormal ECG for the identification of cardiac abnormalities, and a very low positive predictive accuracy (7%) (4). In an unselected athletic population, ECG abnormalities are less common. In a large population of unselected athletes (n = 32,652), the prevalence of an abnormal ECG was about 12%, with less than 5% portraying markedly abnormal patterns (6).

A resting ECG is helpful in detecting some underlying diseases involving heart abnormalities, but there are problems associated with the use of a resting ECG in the epidemiological, logistic, financial, and legal arenas. The theoretical reliability, sensitivity, and specificity of ECG have improved within the past several years as a result of three recent consensus conferences (2010, 2012, 2013) and a retrospective ECG analysis (2014) on the interpretation of tracings in athletes (7–10).

When an ECG is abnormal, risk stratification is based on echocardiography, graded exercise stress testing, ambulatory cardiac event monitoring, and/or cardiac magnetic resonance imagining/coronary computed tomography angiography, if indicated. This approach may reduce sudden cardiac arrest or death during and away from sports by restricting those athletes deemed at high risk for SCD related to participation in physical activity. A multicenter study in Germany on the role of ECG is now underway to investigate the efficacy of this approach in athletes.

Arguments Against Universal ECG Screening for Athletes

ECG screening is not universally accepted as an effective strategy to reduce SCD. In contrast to the Italian experience, Israel implemented a similar mandatory ECG screening program, but has not reported any reduction in SCD (11). In some countries where it is required, ECG screening was instituted by legislative action possibly as a response to a cluster of athlete deaths and not by data-driven decision making. There are no discernible differences in SCD rates between countries that require PPEs with ECGs and those that do not require ECGs (Table 2). While it is accepted that an ECG can detect some cardiac abnormalities, it is not clear that the addition of an ECG will change SCD outcomes or “do no harm” (12,13). For example, a mathematical modeling of population risk and benefit using the Italian data applied to the UK athlete population concluded that a required ECG would be of more harm than benefit from a public health perspective, with a small impact on population health and a potentially great cost to athletes with unnecessary restriction of activity due to false positive findings (14). The end result of the analysis demonstrated that preventing one SCD each year would exclude nearly 800 athletes from competition (14). In addition, a number of athletes, whose tests were falsely negative, would die or suffer significant morbidity (14). It does appear that some sub-populations are at greater risk and may benefit or have benefitted from ECG screening (Table 2). Utilizing question sets aimed at SCD risk (syncpe, family history, etc.) functionally increases the pre-test probability of high risk conditions. Case finding use of ECG causes less harm across the population of athletes and reduces the portion of athletes who are unnecessarily restricted by false positive studies. For a detailed comprehensive review of ECG screening for detection of cardiovascular disease in healthy 12- to 25-year-old young people, the reader is referred to the 2014 American Heart Association – American College of Cardiology Scientific Statement (13).

Panel Conclusions on ECG Screening

The panel did not reach consensus as to whether ECG screening should be used for every athlete or only in case-finding
evaluations. At present, we have insufficient evidence on whether to perform ECG screening in all athletes. Cost, iatrogenic complications, and unnecessary activity restrictions due to false positive findings must be considered when deciding on mandated ECG screening. The ECG may be important in specific populations that have an evidence base to show increased risk and should be a part of the exam for anyone with truly positive responses and supporting history to the risk-based cardiac screening questions. The group agreed that we were unlikely to achieve consensus on the controversial topic of ECG screening in the absence of further data, but the lack of consensus should not preclude our progress on the important concept of developing a universally accepted PPE. Indeed, our lack of consensus in this area underscores the need for future research.

### Human-Centered Design for the PPE

The PPE is an opportunity to screen for risk factors and health problems in large captive populations exposed to sport and physical activity that place large loads on metabolic systems and skeletal structures (15,16). These loads can cause disease and injury, as well as unmask preexisting, but clinically asymptomatic, illness and injury. In practice, the content and structure of the PPE varies widely, there is no uniform mechanism for collecting important information on injury and illness, and its efficacy is unknown (17). One of the reasons the ideal PPE has not yet been built is that the scientific evidence for each component has not yet been established and the sense that we must wait for sufficient evidence to proceed. However, that view falls victim to the assumption that scientific evidence for the PPE is the only way forward. The human element (necessity, desirability, value) is essential in the design and implementation of the PPE, reflecting the disparate groups, needs, and cultures of the potential populations being screened. Complex systems, such as population screening, tend to be in conflict with the reductionist approach, making this process difficult if both are not simultaneously considered (18). The PPE has several substantial challenges: the goal of thoroughly and comprehensively evaluating risk in every organ system; the inefficient utilization of time and resources; the low detection of positive findings; the lack of accuracy and...
precision (sensitivity and specificity) of the questions; the sheer volume of large populations at risk; and the fact that many PPEs are still paper based. An electronic approach to the required PPE, using human-centered design (19–21), would be comprehensive, would provide an exceptional database given the PPE is mandatory in many locations, would greatly simplify PPE administration, and would allow remote access to the results and data for improved preparation, planning, study, and policy implementation.

There are numerous benefits associated with the PPE, irrespective of its ability to reduce injury and illness. For example, for about half of the athletes who get a PPE, it is the only contact that person has with a health provider. Therefore, the PPE is often the only opportunity to provide health counseling related to sport, social, health, and behavioral risk factors. Once a desirable, robust electronic version is created, a wealth of information related to sensitivity, specificity, and overall accuracy will result from data analysis. In addition, an electronic version of the PPE would facilitate the development of a database for policy implementation, and could potentially bring the PPE into the modern era of smart phones and social media, in which young athletes increasingly operate.

It is a good time to consider a major overhaul to the PPE, using a human-centered design approach to aid in implementing a comprehensive, standardized electronic format. Human-centered design will help developers understand the correct questions to ask and drive innovation through understanding the important human factors that influence implementation and utilization of the PPE. The hallmarks of a human-centered approach include understanding, observing, synthesizing, ideating, rapid prototyping, and iterating (Fig. 1).

The key is to incorporate scientific evidence, where available, with a human-centered design approach to improve the current process.

**Summary Statement**

The nomenclature used in the PPE revolves around the concept of the periodic athlete health evaluation. From a public health perspective, the evaluation is best characterized by the IOC Consensus Statement on Periodic Health Evaluation of Elite Athletes: “There is insufficient evidence to date to mandate any specific screening tests for athletes apart from those recommended for the general population” (17). Although the PPE is an accepted past practice based on expert opinion, the question remains: Does the PPE make a difference in athlete outcomes, and what can be done to improve outcomes?

The work group will examine noncontroversial components on which we agree (e.g., lower extremity motor control screening) and controversial ones on which we may not agree (e.g., ECG). The work group will elicit feedback from athletes, parents, coaches, medical providers, and others to ensure that it meets all user needs. One strength of having worldwide consistency in the PPE would be the ability to compare populations more easily. To make progress, the work group will need alignment on a vision and strategy that includes an electronic PPE that is evidence directed, tailored for data acquisition, human centered, efficient, user friendly, and developed with industry partnership.

The role of the screening ECG in reducing cardiac death is both a substantive and controversial issue, but cardiac death during sports participation is rare and not the only PPE issue that deserves attention. There are other important topics that could be highlighted, such as a general vs. symptom-focused exam, screening for risk factors vs. a general physical exam, and paper vs. electronic exam formats. Are we doing something different than periodic health exam in a nonathlete? Yes, athletes have differing risk profiles from nonathletes, and risks vary from sport to sport. The PPE as an injury reduction strategy should start with conditions that have a high prevalence, as common conditions are different in an athlete than in a sedentary person of the same age: concussions that interrupt participation and learning; eating disorders that have lifelong metabolic consequences; and knee injuries that result in severe osteoarthritis 10–15 years earlier than sport-matched peers. Athletes are injured and die in non-sports-related activities from accidents, high-risk behaviors, poor choices, drugs, and depression/suicide; can the PPE be an instrument to reduce both sport-related and all-cause death and injury?
The ideal PPE will bring together athlete-focused screening (detect and exclude) and optimum care for athletes as individuals with health-related needs beyond sport participation. The PPE can become a strategy to detect, exclude, and manage conditions critically important to athlete outcomes in a cost-effective manner. It can promote physical activity for all and for a lifetime. It can be more than simply a clearance for activity. If we can implement an electronic PPE with a central data repository, we can then begin to answer the following key questions that may improve athlete outcomes:

- What is the prevalence of general medical conditions in athletes compared to nonathletes?
- What is the prevalence of disorders that primarily affect athletes?
- Does the prevalence of athlete-related disorders change with age?
- Should the exam vary with age and/or sex?
- Are there low-, medium-, and high-risk sports activities with differing PPE requirements?
- At what interval should the exams be completed (every 1, 2, 3, or 4 or more years)?
- Should exam intervals be based on level and/or risk of sports participation?
- How do we research the issues to direct future exams and care for athletes?
- Can the PPE be used to reduce both sport-related and all-cause death and injury?
- Where and how do we implement programming with a human-centered and evidence-based approach?

Conclusion

There is much to be learned about the PPE and its potential to improve athlete outcomes for prevention of injury, illness, and sudden death. We recommend creating, using human-centered design, an electronic version of the PPE that includes a central database within the member organizations to standardize implementation and to evaluate the effectiveness of the question sets. There are less controversial areas than adding a screening ECG to the exam, which can be the initial focus of this cooperative venture that will have greater impact on larger numbers of athletes around the world. ACSM and FIMS have an opportunity to promote meaningful improvements in the format and use of the PPE.

Our group vision is to improve the PPE content and experience by promoting an internationally accepted tool that is accurate, comprehensive, and standardized for assessing athlete readiness to play as well as conducting research and creating policy. The working group will assess the available electronic versions of the PPE for international use in athlete evaluation and create a centralized database to allow international reporting and tracking of outcomes data and adverse events. An electronic PPE program instituted worldwide with integrated research questions would constitute a novel and significant contribution to the field that can help shape PPE policies for athletes based on age (Table 1), sex, ethnicity, level of competition, and sport-related goals. The work group will be detailed about how this initiative can provide evidence-based recommendations, cost-benefit ratios, and relevance in the future.

The goal of future meetings will be to affirm the vision and strategy, and to present a plan to the Boards and membership of ACSM and FIMS. It is through such a collaboration that the greatest impact on long-term athlete health can be realized.

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