REVIEW ARTICLE

# The Pre-Participation Examination for Leisure Time Physical Activity

## General Medical and Cardiological Issues

Herbert Löllgen, Dieter Leyk, Jochen Hansel


## SUMMARY

Background: There is current debate on the appropriate type and extent of medical testing for amateur and hobby athletes before they engage in sports. In particular, views diverge on the value of an ECG at rest.

Methods: We selectively searched the Medline and Embase databases for relevant publications that appeared from 1990 to 2008. The most pertinent ones are discussed here along with current reviews and guidelines that give recommendations on pre-participation testing for amateur athletes.

Results: History-taking and physical examination are standard around the world. The American guidelines on pre-participation examination do not recommend an ECG at rest, yet the guidelines for most European countries explicitly recommend it. No prospective cohort studies have been performed to date that might provide high-grade evidence (class and level) to support this practice. We discuss the pros and cons of an ECG at rest and also present the guideline recommendations on exercise-ECG testing for amateur athletes over age 40.

Conclusion: In accordance with the current European recommendations, and in consideration of the risks of athletic activity, we recommend that all persons participating in sports should undergo a pre-participation examination that includes an ECG at rest. Although primary-prevention campaigns advise physically inactive persons to get regular exercise, prospective studies are still lacking as a basis for recommendations in this group.



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The pre-participation examination in sports medicine enables the physician to identify clinically latent or already present diseases that could pose a danger to health if the patient were to engage in intense physical activity. In rare cases, life-threatening conditions can occur, followed by death or resuscitation. The goal of the pre-participation examination is to make athletic activity as safe as possible by minimizing the associated risks to health. This also includes disease prevention.

An Internet-based poll of endurance athletes revealed that only 85% of sports medicine consultations included a physical examination and only 67% included an ECG at rest (1). In the current literature, there is a lack of agreement on the proper content and extent of the pre-participation examination for either leisure-time or high-performance athletes (2–5, e1–e4). In this article, we present general medical and cardiological aspects of the pre-participation examination.

## Methods

A selective search of relevant literature published from 1990 to 2008 was performed in the Medline and Embase databases, on the basis of the following search terms:

- pre-participation examination
- leisure-time sports
- cardiac risk
- sudden death during sporting activity
- ECG
- stress ECG.

An extensive list of references can be found at www.dgsp.de. For the present article, we also made use of review articles, books (13, e6), guidelines, and recommendations (5, 6, 22, e1–e7).

## Risks from exercise and sports

The risk of cardiovascular complications during sporting activities is higher in persons who are just beginning to participate in sports or are starting again after an interval of inactivity, as well as in persons over age 35 with latent diseases (6–9, 10, 13, e8–e12). The risk of a cardiac event during intense sporting activity is 15% to 50% higher in the first few hours of the activity,

especially in restarters (e6, e13–e18). The number of expected deaths per 100 000 persons engaging in sports per year lies in the range of 0.5 to 1; in Italy, the corresponding figure is 2.1 deaths per 100 000 persons who are active in sports and 0.8 deaths per 100 000 persons of comparable age who are not active in sports (6, 8, e4, e19–e22). The overall death rate in the normal population over age 35 is 1 to 2 deaths per 1000 persons per year (6, 7, 19). An American case registry documents an increasing number of deaths in recent years, most commonly in (American) football, basketball, and soccer, with marathon running in 14th place (8). These increasing numbers in the American registry are due to improved documentation, greater awareness among physicians, and better reporting (8).

The causes and frequency of cardiovascular complications vary from one cohort study to another *(Figure 1)* (e8–e10, e22). Hypertrophic (obstructive) cardiomyopathy (abbreviated HCM or HOCM) is common in the USA because of its high prevalence among Afro-American athletes; it is much rarer among Caucasian athletes, and in Europe (11). In a study carried out in Italy, arrhythmogenic right-ventricular dysplasia (ARVD) (9, 10, e22) was found to be a common cause. In other studies, the most common finding was a structurally normal heart (6, e8–e10, e22) *(Figure 1)*. A post-mortem genetic study („molecular autopsy") is now recommended in cases of unexplained death during sporting activity (9, 10).

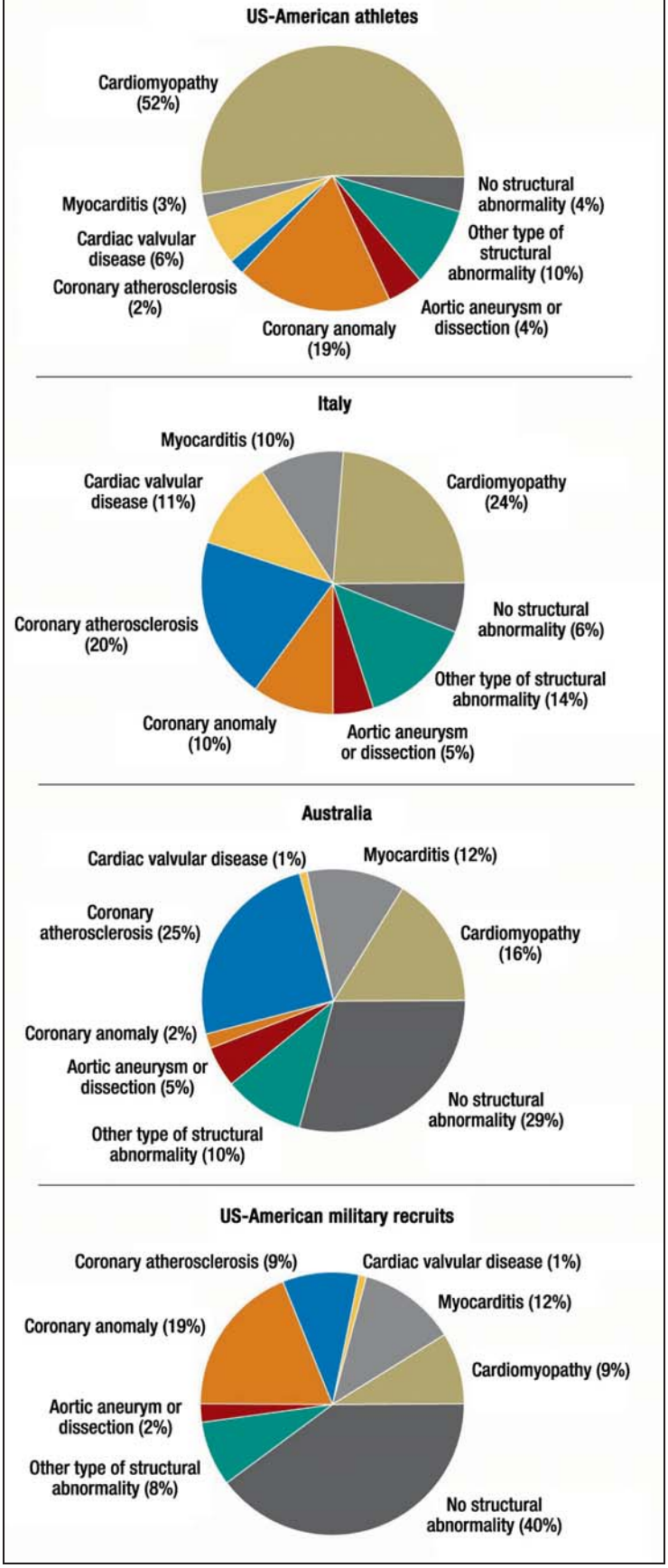
Among persons over age 35 or 40 (depending on the study; e23), coronary heart disease is the most common cause of cardiac events during sporting activity (6, 8, 19, e6, e22, e24). All over the world, similar recommendations have been issued for further evaluation in this age group (2–5, 23, e1–e5).

## The pre-participation examination in sports medicine

Recommendations regarding the pre-participation examination are based on scientific evidence insofar as relevant studies are available (19, 13, 23, e4, e5, e14, e24–e25). The target groups for evaluation are new participants and restarters in amateur athletics and ambitious leisure-time sports, regardless of age. An Italian retrospective study involving more than 34 000 subjects revealed sports-associated deaths to be less common in persons who had undergone pre-participation examinations by qualified sports physicians (e3). As no large-scale, prospective cohort studies have been performed, there remains disagreement about recommendations in the areas of general medicine and cardiology. There is a consensus, however, that the pre-participation examination in sports medicine should include the following (evidence level C) (4, 5, 12, 13, 19, e1–e7, e26–e29):

- a general medical history and sports-related history, with a standardized questionnaire followed by supplementary questioning by a physician;
- a physical examination;
- an ECG at rest performed and interpreted by qualified personnel.

**FIGURE 1**



**BOX 1**

### Typical abnormal findings on rest ECG: evaluation and interpretation depending on history and physical findings

- Signs of left ventricular hypertrophy without endurance training
- AV block without endurance training
- Q waves arousing suspicion of prior ischemic event(s) (coronary heart disease?)
- Repolarization abnormalities with or without deep negative T waves
- Transient ST segment elevation
- Prolonged or shortened QT interval
- Pre-excitation (delta wave)
- Repolarization abnormalities: epsilon wave
- (atypical) Right bundle branch block arousing suspicion of Brugada syndrome (physical findings!)
- Left bundle branch block (permanent or intermittent)
- Atrial fibrillation (intermittent, persistent or permanent, in some cases at night or associated with bradycardia)

**BOX 2**

### Causes of cardiac events among athletes

- Cardiomyopathy
  - hypertrophic
  - with/without outflow obstruction
  - dilated, "non-compaction"
  - arrhythmogenic, right or left ventricular (ARVD, ALVD)
- Ion channel diseases:
  - long or short QT syndrome (LQTS, SQTS)
  - Brugada syndrome
  - pre-excitation syndrome (with intermittent atrial fluctuation)
  - catecholaminergic polymorphic ventricular tachycardia (CPVT)
  - early repolarization
- Coronary anomalies, aortic aneurysm or dissection, myocarditis
- Cardiac valvular disease, Marfan syndrome
- Coronary heart disease:
  - particularly in athletes over age 35
  - when more than one risk factor is present
  - in the presence of arterial hypertension (severe)

#### History

A number of different historical questionnaires have been developed for persons participating in sports (12). A simple and popular one is the Canadian PAR-Q (12, e13, e15) (http://uwfitness.uwaterloo.ca/PDF/par-q.pdf). The prospective athlete answers seven easy questions; if any are answered in the affirmative, a medical examination is definitely recommended. This questionnaire is meant as a guide only, yet it is adequately validated, specific, and reliable, especially for persons over age 35 (e13, e15). It is administered to nearly all persons applying to run in city marathons in Germany. These persons are thereby alerted to the health risks, and they are advised to get a medical examination if they answer any question „Yes."

Other, more extensive sports history questionnaires have been published (12). The one used in the German-speaking countries is based on a consensus recommendation derived from many years of clinical experience in sports medicine (12). Most of this three-page questionnaire can be filled out by the prospective athlete him- or herself; only a few questions require additional questioning by a physician. No large-scale prospective studies have been published regarding the use of historical and clinical data to reduce the risk of cardiac events. The current evidence suggests that the ECG at rest is a much more sensitive test than the history and physical examination (5, 19, 23, 24, e19, e24–e28).

Family history is particularly important (13, 14). If there is any history of premature death in a near relative, or of a known, hereditary disease such as Brugada syndrome or cardiomyopathy, a detailed cardiological examination is needed. Persons complaining of syncope, palpitations, dizziness of unknown cause, chest pain, or unusual exertional dyspnea should also undergo further diagnostic assessment. Anyone over age 45 who participates in sports should be tested for coronary heart disease, particularly if one or more risk factors are present (12–14, e24). Current and previous sporting activities should always be asked about so that potential risks can be assessed at the start of training.

#### Physical examination

The pre-participation examination should always include a physical examination with blood pressure measurement (1). The physician should look for malformations, skin changes (e.g., acne as a sign of anabolic steroid abuse), and anomalies and variations such as those of Marfan syndrome (e24), which are more commonly seen in tall athletes (basketball players, volleyball players, rowers) (2, 12, 13, e1, e2). Meticulous auscultation of the heart in the supine and sitting positions, and with a Valsalva maneuver, enables the physician to detect the position- or loading-dependent bruits of mitral valve prolapse and HCM. Pulsus bisferiens (biphasic pulse) arouses suspicion of HOCM, while fixed splitting of the second heart sound indicates an atrial septal defect (ASD).

### ECG at rest

There is disagreement about the importance of an ECG at rest as a component of the pre-participation examination (evidence level IIa/C) (3, 5, 14, e35). It is required in nine European countries and recommended in six (5). In Germany, an ECG at rest is recommended for persons aged 12 years or older who are beginning to participate in sports. For persons aged 35 or older, an ECG at rest is recommended once every two years, if there are any corresponding symptoms, as part of the statutory medical insurance check-up ("Check-up 35") and the preventive examination in occupational medicine.

In the USA, an ECG at rest is not routinely included in the pre-participation examination for persons about to undertake sporting activities (15). The current guidelines of the American Heart Association (AHA) (3, e2, e4–e5, e35) recommend one only for persons aged 40 or older (3). A number of studies have addressed the validity of an ECG at rest for persons participating in sports. Of 158 persons who died suddenly during sporting activities, 134 were found to have had heart disease; the sports-medicine check-up without an ECG at rest had aroused suspicion of cardiovascular disease in only 3% of cases (e10, e21). Two prospective, small-scale studies of school children revealed abnormal findings in 0.2% and 2% (e15, e16), while a much larger Italian study revealed abnormal findings in 11.8%, of which 4.8% (e23) were pathological and led to exclusion from sports. According to the Italian data, which covered a 25-year period, 95% of persons with HOCM had pathological findings (23).

Physicians without extensive experience in the interpretation of ECG's may have difficulty interpreting an athlete's ECG at rest. This requires special cardiological knowledge relating to sports, in particular with respect to hypertrophic, dilated, and arrhythmogenic right and left ventricular cardiomyopathies (ARVD, ALVD), as well as ion channel disorders such as the long and short QT syndromes (LQTS and SQTS) and Brugada syndrome (11, 17–19, 21, 24, e25). The recommendations of Corrado et al. (4, 6, 12, e1) are considered standard for the interpretation of an athlete's ECG. Minor differences between the American and European criteria for pathological findings in the "sports ECG" concern the QT duration, Wolff-Parkinson-White (WPW) syndrome, ventricular extrasystoles, and transient ventricular tachycardias (4).

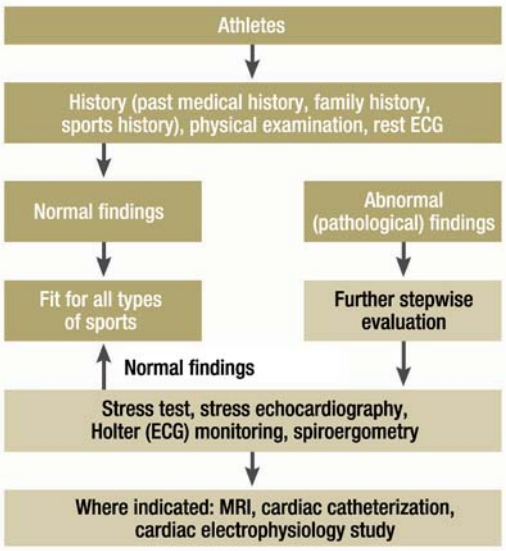
While history-taking and a physical examination are universally recommended as basic elements of the pre-participation check-up, the role of an ECG at rest for prospective athletes is still a matter of debate.

## The ECG at rest: pro and con

### Arguments against performing an ECG at rest

- Normal variant findings in the ECG at rest are common in high-performance athletes and less common in leisure-time athletes. Negative T waves are common, and not pathological, up to age 16 and in Afro-American athletes (6, e6, e19, e25, e28, e29).
- Misinterpretation and false-positive findings are not uncommon, even in expert hands (15).
- Physicians interpreting the ECG who do not have special expertise in sports cardiology can miss the diagnosis of newly appreciated entities such as ion channel diseases or cardiomyopathies *(Box 1)*.
- Some heart diseases are not accompanied by any typical ECG changes (Marfan syndrome, coronary heart disease).
- The sensitivity and cost-effectiveness of the ECG at rest are low (15, e19, e24, e25, e38), and false-positive findings entail considerable further costs (e23, e25, e38).

**FIGURE 2**




### Arguments in favor of performing an ECG at rest

- An ECG at rest is relatively inexpensive and can be obtained in many physicians' practices (including those of sports physicians).
- Typical pathological findings, such as deep negative T waves, are common, particularly in HOCM (82%); other diseases can also manifest themselves with negative T waves or other changes, such as epsilon waves (high sensitivity) (4, e1).
- Left bundle branch block and certain types of right bundle branch block indicate the presence of structural heart disease (4) *(Box 2)*.
- The current diagnostic criteria (4, 12, 13) standardize and simplify the interpretation of ECGs and improve diagnostic accuracy (4, e1–e3).
- False-positive findings are less common in younger athletes and less well trained individuals than in high-performance athletes.

**BOX 3**

## Evidence of possibly pathological ECG changes in persons engaging in sports (from e1, 16)

- P wave:
  - Left atrial enlargement: negative portion of P wave in lead V1 >0.1 mV deep and >0.04 s long
  - Right atrial load: enlarged P waves in leads II and III, or amplitude in V1 >0.25 mV
- QRS complex:
  - Vector in the frontal plane: right axis deviation (> +120°) or left axis deviation – 30 to – 90°
  - Increased voltage: R or S amplitude in the limb leads >2 mV, S in V1 or V 2 >3 mV, or R in V5 or V6 >3 mV (see also Sokolow-Lyon Index)
- Abnormal Q wave:
  - Duration longer than 0.04 s or >25% of the height of the following R-wave or QS waves in two or more leads
  - Right or left bundle branch block with QRS duration >0.12 s
  - R or R' wave in lead V1 >0.5mV and R/S ratio >1
- ST segment , T wave, QT duration:
  - ST depression or T-wave flattening or inversion in 2 or more leads
  - Prolongation of the frequency-corrected QT duration beyond 0.44 s (men) or 0.46 s (women)
- Arrythmias and conduction abnormalities:
  - Complex ventricular arrhythmias (salvoes, couplets, ventricular tachycardias are considered abnormal)
  - Frequent ventricular extrasystoles (> 30/hour or > 1000/24 hours) are considered to lie in a "gray zone" between normal and abnormal
  - Supraventricular tachycardias, atrial flutter or fibrillation
  - Shortened PQ interval (AV time) (<0.12) with or without delta wave
  - Sinus bradycardia with heart rate below 40/min at rest (although this can be a normal finding in high-performance athletes)
  - 1st[*1], 2nd, or 3rd-degree AV-Block (this can also be a normal finding in high-performance athletes)

[*1] No shortening on hyperventilation or brief exercise

Comments:
"Atypical" right bundle branch block: evaluation for Brugada syndrome or ARVD
Prolonged QT duration: evaluation for a congenital or acquired long QT syndrome
Shortened QT duration can also be abnormal (so-called short QT syndrome), but note: trained athletes can also have a prolonged QT duration
Slow („slurred") initial QRS upstroke (delta wave): evaluate for WPW syndrome. Note: in WPW syndrome, Q waves must be absent in I, aVL, and V6, as septal activation is missing.

- Abnormal ECG findings "disqualify" some 2% of prospective athletes from high-performance sports but can also save lives (4, 5, 16–19, e5, e25).
- If heart disease is diagnosed, it might be possible (depending on the specific diagnosis) to protect the patient's relatives from adverse cardiac events through further testing (e.g., echocardiography) (4, 13, 14, e2, e4, e19, e23, e24, e30).
- An Italian population-based study found an association between the performance of ECGs at rest and a marked decline in sudden deaths (e3): in 25 years of observation, the rate of sudden death dropped from 3.5 to 0.6 per 100 000 person years.

**Consideration of the argument for ECG at rest**

The expertise of persons performing sports-medicine evaluations varies from country to country: in the USA, some sports-medicine evaluations are performed by non-physicians, while sports physicians in Italy undergo at least four years of specialized training, including sports cardiology. This type of training is now a desired objective across Europe. No data are available on the cost-effectiveness or sensitivity of sports-medicine evaluations in top athletes in Germany. Preliminary cost-effectiveness calculations for pre-participation sports-medicine evaluations have yielded values between 8000 and 30 000 US dollars per life saved and per quality-adjusted life year (QALY). By current American criteria, these figures imply that such evaluations are worthwhile as a means of saving lives and are, at least, justifiable as a means of improving the quality of life (13, e19).

There are also sound medicolegal and ethical reasons for ECG screening, which have led the International Olympic Committee (IOC) and most European countries to require it (e31, e32).

A 12-channel ECG at rest is, therefore, included in the current recommendations of the European countries and the IOC (consensus recommendation) (4, 12, 13, e4, e31, e32). A still unsettled issue is whether an ECG should be performed in childhood or just before the individual begins participating in sports, as ion channel diseases can already pose a danger to health at an early age (24, e7, e15, e16, e19, e22). When the ECG at rest reveals an abnormality, further evaluation should be performed as indicated in *Figure 2*.

All abnormal findings in the patient's history, physical examination, or ECG at rest require further general medical and cardiological investigation *(Figure 2)*. This investigation can include, for example, transthoracic echocardiography, stress ECG or Holter (ECG) monitoring, or pulmonary function testing, and it should be performed even when the patient has typical exercise-related complaints such as dyspnea, exercise-induced asthma, chest pain, or palpitations—all the more so if the patient has sustained one or more syncopal events. Laboratory tests should be performed as well (12). The proper interpretation of an athlete's ECG requires specific expertise; in case of doubt, a sports physician with knowledge of the relevant cardiology should be consulted (cf. www.dgsp.de [in German]).

An ECG at rest is not a reliable means of diagnosing coronary heart disease, a condition that may be present, but clinically silent, in older athletes. Such persons should, therefore, undergo a stress ECG (6, 15, 20, e14, e33, e34).

**BOX 4**

**Indications for stress ECG in asymptomatic persons (without any known coronary heart disease)**

- Class I: None
- Class II:
  - Presence of multiple risk factors
  - Age over 45 years (men) or 55 years (women)
  - Before physical training
  - Occupations in which heart disease could endanger public safety
  - High likelihood of coronary heart disease, peripheral arterial occlusive disease, chronic renal failure, etc.
- Class III: Routine examination of asymptomatic persons (15, 20, e14)

## Stress ECG

A stress ECG aids in the recognition of coronary ischemia, arrhythmia, and blood-pressure changes on exertion (16, 18–20, e15, e33, e34). Ergometric data are not only of diagnostic use, but also serve as the basis for training recommendations (16, e33).

A stress ECG is not a standard element of routine pre-participation testing (18, 19). According to the guidelines, it is indicated only in older persons (men over 45, women over 55) who are about to undertake intensive physical training *(Boxes 1 and 3)* (16, 18, e15, e33, e34). In this age group, the positive predictive value of a stress ECG is approximately 85%, with pretest probability 21% and specificity 77% (± 17%). The evidence underlying the guidelines' recommendations is of level IIb (16, e33, e34).

For asymptomatic persons who have no risk factors and are under age 55, the guidelines give an optional recommendation for a stress ECG (16, 18, 19) *(Box 4)*. Stress ECG testing is recommended for persons over age 45 who have more than one risk factor and are about to undergo intensive physical training (evidence level IIb, guidelines of the AHA, ACC and DGK [12, 16, 18]). A stress ECG is mandatory, however, for persons of any age who have cardiac symptoms, and for persons over age 65 with or without symptoms (12–19, e33, e34). A stress ECG is not indicated if the Framingham Risk Score (FRS) is less than 0.6 but is indicated if the FRS is greater than 2.0 (15, e15). The

FRS is derived from a combination of clinical data (age, smoking status, blood pressure) and laboratory values (total cholesterol, HDL-cholesterol).

The AHA generally does not consider stress ECG testing mandatory for asymptomatic persons about to undergo moderate training, as the risks of such training are low, while the test is expensive and unlikely to yield useful information, and the interpretation of its findings is fraught with uncertainty (20). Thus, stress ECG testing should be performed only in accordance with the guidelines, and attention should be paid to quality control. A common error in stress ECG testing is inadequate stress (12, 15, 18–20, e14, e33, e34). For overweight or obese persons, the current state of the data on stress ECG testing is uncertain, but the same recommendations are in effect, so that cardiac events can be prevented in this group at elevated risk.

## Repeating the pre-participation examination

No prospective studies shed light on the question whether the sports-medicine pre-participation examination should be repeated, and, if so, when. The current literature consistently recommends repeating the preventive examination as follows:

- every 2–3 years in persons under age 35;
- every 1–2 years in persons over age 35, or who have more than one risk factor, or whose examination reveals an abnormal finding (4, 12, e14, e27);
- persons who have developed new symptoms or signs of disease should undergo an additional short-term examination.

## Overview

The content and extent of the pre-participation examination in sports medicine are currently debated in the USA and Europe, particularly with respect to the ECG at rest; the cost factor plays a much larger role in the USA (13, 21–24, e24–e26, e30, e35, e36, e38, e39). To date, there have not been any large-scale, prospective, multi-center cohort studies with hard endpoints (mortality and cardiac morbidity) and with long-term follow-up of defined groups of athletes. Such studies will be needed for an accurate determination of the costs and benefits of preventive testing, and, in turn, for a judgment of its proper extent. It is recommended that the ”Check-up 35” now routinely performed in Germany should be supplemented with a pre-participation sports-medicine examination serving the aims of disease prevention, suitability testing for sports, lifestyle counseling, and counseling for athletic training.

In Germany, as elsewhere, figures on the frequency of medical complications in sports are lacking. In sporting events that involve large numbers of people, such as city marathons, the participants’ medical care and their rate of complications should be prospectively studied with the aid of an anonymized questionnaire filled out by the organizers. This is the only way to determine the risk of participating in sporting events such as community runs, marathons, or triathlons, and to gauge the utility of preventive medical examinations. Such prospective studies will require the collaboration of event organizers and medical rescue services. A questionnaire of this type already exists (personal communication from T. Rüther). In cases of sudden death during sporting activity, a maximally standardized medicolegal autopsy, including a so-called molecular autopsy, might yield important findings (9, 10).

For ethical, medicolegal, and medical reasons, there is now a consensus recommendation (IIa, C) for a pre-participation sports-medicine examination; the proposed standard consists of a uniformly obtained clinical history, physical examination, and ECG at rest interpreted by a qualified specialist. This proposed standard is based on the recommendations of the International Olympic Committee (IOC) and of the American and European societies of cardiology, sports medicine, and pediatrics. Public organizations, governmental authorities, the World Health Organization, medical societies, and associations of sports physicians currently advise everyone to take regular physical exercise for the primary prevention of disease. It follows that anyone willing to take this advice should be offered a preventive medical examination, in qualified hands, to minimize the avoidable cardiac risk.

**Conflict of interest statement**
Professor Löllgen has received lecture honoraria from BayerVital.
The other authors state that they have no conflict of interest as defined by the International Committee of Medical Journal Editors.

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**Dedication**
This paper is dedicated to Professor W. Hollmann on the occasion of his eighty-fifth birthday.

Translated from the original German by Ethan Taub, M.D.

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