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Comprehensive Approaches in Sports Preparticipation Medical Evaluation

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ABSTRACT

Purpose: With the increasing global participation in sports across all demographic groups, the need for Preparticipation Medical Assessment (PME) is of paramount importance. This article examines the multifaceted nature of PME, encompassing nutritional, psychological, and musculoskeletal assessments as well as the importance of cardiac evaluation. The primary aim of this comprehensive approach is to prevent Sudden Cardiac Death (SCD) and mitigate risks, such as musculoskeletal injuries and Relative Energy Deficiency in Sport (RED-s), that may occur during the season, ultimately ensuring the long-term health and safety of athletes. This review aims to guide a broad audience, including sports physicians, coaches, physiotherapists, athletes' parents, and medical students, by examining the current approaches, components, and practices of PME in Türkiye, while also considering approaches in other countries. The primary objective is to highlight the critical role of PME in athletes' health, explain methods for identifying risk factors, and summarize current guidelines for assessing athletes' fitness for sport.

Keywords: Athlete examination; Preparticipation; Sport; Sudden cardiac death; Sports medicine

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INTRODUCTION

Sport has become a significant activity embraced and practiced by large populations worldwide. This widespread participation is observed across both younger age groups and older individuals. According to 2023 data from the United States, the sports participation rate for children aged 6-17 was approximately 55% (State of Play, 2026). By 2024, this rate is reported to have increased by 6%. Similarly, a notable increase in sports participation has been observed among older individuals, referred to as "master athletes", in recent years (Graziano et al., 2023). In Türkiye, according to World Health Organization (WHO) data in 2022, among adult population 78% of men and 61% of women are classified as physically active (World Health Agency, 2026). As participation in sports increases, there may be an increase in sports-related mortality and morbidity. Individuals with undiagnosed medical conditions, especially those who engage in sudden and high-intensity exercise, may face a variety of health risks, including, less frequently, serious cardiac events (Franklin et al., 2022). This phenomenon, often referred to as the "exercise paradox" highlights how exercise can reduce long-term cardiovascular risk while simultaneously triggering acute cardiac events in susceptible individuals. This increased participation highlights the importance of comprehensive evaluation processes to protect athletes' health and minimize injury risks (Maron, 2000).

In this context, Preparticipation Medical Evaluation (PME) emerges as a critical tool for determining athletes' general health status, identifying injury risk factors, and assessing their suitability for sports. A comprehensive PME should include various components to fully understand the athlete's health and suitability for sports. History includes family background, lifestyle, previous medical history and cardiac symptoms (chest pain, shortness of breath, palpitations, syncope). These components cover a wide range, from the athlete's medical history to their physical examination.

Medical History

In PME, a complete medical history is vital as it can identify up to 88% of general medical conditions and 67-75% of musculoskeletal disorders. It provides important clues about the athlete's current health status and identifies areas to focus on during the physical examination. Various forms can be used to collect information about medical history; if the athlete is a minor, these forms should be completed with the athlete's parent or guardian (MacDonald et al., 2019).

According to the 2021 American College of Sports Medicine recommendations, the self-administered Physical Activity Readiness Questionnaire (PARQ+), an international standard for risk stratification and screening in recreational athletes, is recommended (Ozemek et al., 2019, Warburton et al., 2011). PME and PAR-Q+ are tools used to assess physical readiness. Regarding cardiovascular health, positive personal history criteria are exertional chest pain/discomfort, syncope/near syncope, irregular heartbeat/palpitations, shortness of breath, severe fatigue with exercise. Positive family history criteria are existence of a close relative who had experienced premature heart attack or sudden death (<55 years of age in males and <65 years in females), or in the presence of a family history of cardiomyopathy, Marfan syndrome, long QT syndrome, Brugada syndrome, severe arrhythmias, coronary artery disease, or other disabling cardiovascular diseases (Corrado et al., 2005). Athletes should be evaluated in this respect.

Components and timing of assessment vary according to countries. PME in Türkiye is mandated by the law "Regulation Amending the Regulation on Athlete Licensing, Registration, Visa and Transfer," published on 1 December 2012. According to the law, athletes are divided into two groups: registered (licensed) and recreational. Registered athletes need to get medical permits from a physician to engage in sports. Recreational athletes need to carry a sports card which includes written health declaration by the athlete himself. The yearly examinations are carried out by physicians who have expertise in sports medicine, family medicine or cardiology. History, physical examination and electrocardiogram (ECG) are key components. For every registered athlete 12-lead ECG is recommended on a yearly basis (Türkiye Spor Hekimleri Derneği, 2018).

The athlete's current medications and over-the-counter supplements should be reviewed, considering the World Anti-Doping Agency (WADA)'s list of prohibited substances, along with their potential side effects (WADA, 2025). Using the provided list of prohibited substances, the physician could discuss potential illicit uses that could lead to the athlete's disqualification. Medications necessary for the treatment of chronic conditions must be documented separately as a "therapeutic use exception". The athlete must be informed about doping.

The patient's allergens (both drug-related and environmental), the nature of the reaction, and history of anaphylactic reactions must be thoroughly investigated.

The athlete's current nutritional status should be thoroughly investigated. The Eating Disorder Examination Questionnaire (EDE-Q) questionnaire can also be used to evaluate eating disorders (Fairburn et al., 2008). The female athlete triad is a broader syndrome introduced by the International Olympic Committee (IOC) in 2014 that screens for relative energy deficiency in sport (RED-s) (Heikura et al., 2023). Low energy availability is the core problem of RED-s and is associated with poor performance, decreased strength, delayed recovery, low bone mineral density, impaired psychological, immune and cardiovascular health in the short term and can lead to multi-organ system dysfunction in the long term. RED-s is reported to affect 22–58% of male and female adolescent athletes. If an athlete has symptoms such as menstrual irregularities, eating disorders, stress fractures, fatigue, and decreased performance, RED-s should be considered and evaluated from this perspective (Blese et al., 2024). Diagnosing energy deficiency is difficult, but different questionnaires found in the literature can be used. For example, specific tools such as the RED-s Clinical Assessment Tool (RED-s CAT2) or the Low Energy Availability in Females Questionnaire (LEAF-Q) and Low Energy Availability in Males Questionnaire (LEAM-Q) allow for a more detailed screening of energy deficiency. Furthermore, collaborating with a sports dietitian to provide personalized nutritional counseling can help athletes achieve and maintain optimal nutritional status (Mountjoy et al., 2015, Melin et al., 2014, Bronwen et al., 2022).

Taking a complete musculoskeletal history involves a careful examination of previous injuries, including the mechanism of injury, severity, treatment, and any resulting disability. Previous injury or surgery is a known risk factor for re-injury to a specific body part and may necessitate a detailed physical examination of the affected areas.

Participation in intensive training focused on a single sport has increased recently (LaPrade et al., 2016). Both the American Orthopedic Sports Medicine Association and the IOC have issued consensus statements that excessive participation in a single sport is detrimental due to physical and mental health problems (including overuse injuries, burnout, and decreased athletic performance), particularly in the pre-adolescent population (LaPrade et al., 2016, Bergeon et al., 2015). For athletes training hours are another concern. Subsequent studies support the dose-response relationship between weekly training hours and injury risk; specifically, training 3-7 hours per week carried significantly lower risk than training 12 or more hours per week. A study based on athletes aged 7-18 years found that injury risk significantly increased in children athletes who have a higher training hours than their age and had a training hours/free play hours ratio more than 2:1 (Shigematsu et al., 2022). Therefore,

the number of hours spent weekly on their sport and weekly free play hours are important screening questions to ask to determine the future injury risk profiles of young athletes.

Regarding female athlete's hormonal balance is strongly linked to musculoskeletal health however there were limited questions in screening questionnaires about the menstruation length, quality, and frequency, as well as age of menarche. A review based on preparticipation questionnaires found out only 4/41 studies included questions surrounding mental health, and none of them included exercise dependence/addiction in addition to eating disorders which are relatively common among female athletes. To assess female athlete's health fundamental areas which need to be included are general information and training history, musculoskeletal health, energy availability/relative energy deficiency in sport, menstruation and contraception, gynecological/pelvic health, nutrition/eating behaviors, mental health. For a comprehensive female health questionnaire various domains also need to be included, such as breast health, pregnancy/postpartum, and the sport environment (Schultz et al., 2025).

Recently, a cyclical correlation has been described between mental health of the athlete, injury risk, and delayed injury recovery. An American Journal of Sports Medicine study of the National Collegiate Athletic Association athletes found a significant relationship between anxiety/depressive symptoms during the preseason period and subsequent risk of injury to the athlete, and this has been described in various cohorts from the youth to elite levels (Liv et al., 2017, Timpka et al., 2017).

We recommend using two simple screening tools to identify athletes at risk of depression/anxiety. For depression, the nine-item Patient Health Questionnaire (PHQ-9) is validated for identifying depression, while the Generalized Anxiety Disorder 7-item (GAD-7) questionnaire can be used to screen for anxiety. A score of 5 or higher on either scale is considered mild depression and anxiety, respectively, and should prompt the healthcare professional to be more vigilant with these athletes. Additional checks and monitoring for worsening symptoms can be done using the provided scales, and a score of 10 or higher on either indicates the need for referral to a mental health professional (Keenan et al., 2023).

Physical examination

The components of physical examination are abdominal, pulmonary, cardiac examination, bend test to check for scoliosis, weight, height and blood pressure measurement. During abdominal examination, palpation of the spleen and liver should be performed. Further investigation and consultation should be requested if there is an enlarged liver or spleen, or a

palpable mass. Additionally, the athlete should be examined for Marfanoid features. The presence of long limbs and joint hypermobility should be investigated. Athletes with Marfan syndrome often have associated cardiac anomalies. During a pulmonary examination, lung sounds are listened to bilaterally, the degree of equal participation of both lungs in respiration is assessed, and the presence of additional sounds (rales/rhonchi/wheezing) is investigated. After measuring height and weight, the body mass index is assessed. Based on this, the developmental level of the child athlete can be determined, or obesity can be assessed in both child and adult athletes.

Two minutes musculoskeletal examination is recommended for the quick detection of orthopedic problems. The examination includes 14 steps; inspection facing the physician (trunk and upper extremity symmetry), cervical range of motion (ROM) (flexion, extension, rotation, and lateral flexion), resisted shoulder shrug (trapezius strength), resisted shoulder abduction (deltoid strength), shoulder internal and external rotation (glenohumeral joint ROM), elbow extension and flexion (elbow ROM), forearm pronation and supination (elbow and wrist ROM), making and opening a fist (hand and finger ROM), inspection with back to the physician (trunk and upper extremity symmetry), spinal extension (assessment for spondylolysis or spondylolisthesis), spinal flexion facing toward and away from physician (thoracic/lumbar ROM, spinal curvature, hamstring flexibility), lower extremity inspection (alignment and symmetry), 4-step "Duck Walk" (hip, knee, and ankle ROM; strength; and balance), toe and heel standing (calf symmetry, strength, and balance), (Türkiye Spor Hekimleri Derneği, 2018).

Electrocardiogram (ECG)

There are three different ECG findings categories in guidelines: normal, borderline and abnormal. Normal findings are considered nonpathological in athletes and are a result of the adaptations for increased exercise intensity so they require no additional testing if there are no symptoms. Borderline findings are suspicious changes, and they need to be investigated, especially two or more appear on the same recording. Abnormal findings are changes which can't be explained with the remodeling due to exercise but rather pathological signs requiring additional evaluation (Graziano et al., 2025).

In various meta-analyses ECG was consistently more sensitive than history or physical examination for identifying sudden cardiac arrest (SCA) related conditions. Moreover, ECG also produced fewer false positive results than history or physical examination (Rippey et al., 2025). In a study carried out in Italy; positive family history, symptoms, and/or abnormal physical examination identified 29%, and added ECG identified 59% of cases with a risky

pathology (Perez-Pedrigo et al., 2022). American Heart Association (AHA) 14-point evaluation test identified 43.8% of athletes with a risky pathology. The ECG's success rate was 93.8% for these cases (Sarto et al., 2023).

In a study including 4450 elite athletes no additional hypertrophic cardiomyopathy (HCM) diagnosis was made with added echocardiographic examination. All cases with HCM had positive ECG signs (Pelliccia et al., 2001). If there is a lack of expertise for athlete ECG criteria it may increase false-positive rates and overall costs. There were new suggestions, including AI-assisted ECG analysis, that may further support such programs and decrease the necessary costs, however there are not enough validation tests to support such applications. 12-lead ECG is a recommendation of European Football Union (UEFA), International Federation of Association Football (FIFA) and the IOC (Graziano et al., 2025). In adult athletes ECG findings are classified into three categories based on those criteria (Table 1), (Drezner et al., 2017).

Table 1: ECG Interpretation Findings in Adult Athletes

Category	Specific ECG Findings	Clinical Management & Action
Normal ECG Findings	• Increased QRS voltage for LVH or RVH • Incomplete RBBB • Early repolarization/ST segment elevation • ST elevation followed by T wave inversion V1-V4 in black athletes • T wave inversion V1-V3 (if ≤ 16 years old) • Sinus bradycardia or arrhythmia • Ectopic atrial or junctional rhythm • 1° AV block • Mobitz Type I 2° AV block	**No further evaluation required** in asymptomatic athletes with no family history of inherited cardiac disease or Sudden Cardiac Death (SCD).
Borderline ECG Findings	• Left axis deviation • Left atrial enlargement • Right axis deviation • Right atrial enlargement • Complete RBBB	**In isolation:** No further evaluation required, **2 or more findings:** Further evaluation required.
Abnormal ECG Findings	• T wave inversion • ST segment depression • Pathologic Q waves • Complete LBBB • QRS ≥ 140 ms duration • Epsilon wave • Ventricular pre-excitation • Prolonged QT interval • Brugada Type 1 pattern • Profound sinus bradycardia (< 30 bpm) • PR interval ≥ 400 ms • Mobitz Type II 2° AV block • 3° AV block • ≥ 2 PVCs • Atrial tachyarrhythmias • Ventricular arrhythmias	**Further evaluation required** to investigate pathologic cardiovascular disorders associated with SCD in athletes.
AV, atrioventricular; LBBB, left bundle branch block; LVH, left ventricular hypertrophy; PVC, premature ventricular contraction; RBBB, right bundle branch block; RVH, right ventricular hypertrophy; SCD, sudden cardiac death. (Drezner et al., 2017).		

In children athletes ECG findings are classified into three categories based on those criteria (Table 2), (Pieles et al., 2026).

Table 2: ECG Interpretation Findings in Children Athletes

Category	Specific ECG Findings	Clinical Management & Action
Normal ECG Findings	• Sinus bradycardia (>40 bpm) • Respiratory sinus arrhythmia • Junctional escape or ectopic atrial rhythm • Early repolarization • Increased QRS voltages • T wave inversion V1-V4 age <12 years • T wave inversion V1-V3 age <16 years • Isolated T wave inversions V1, III, aVR • Biphasic T waves • Incomplete RBBB	No further evaluation required (in asymptomatic athletes without family history).
Borderline ECG Findings	• Left axis deviation • Right axis deviation • Left atrial enlargement • Right atrial enlargement • Prolonged PR interval (200–280 ms) • Complete RBBB • Mobitz type 1 2° AV block • Low QRS voltages • T wave inversion V1-V4 at 12–14 years	Further evaluation determined on a case-by-case basis.
Abnormal ECG Findings	• Profound sinus bradycardia (HR ≤40 bpm) • Profound 1° AV block (PR interval >280 ms) • Abnormal T wave inversion • Prolonged QT interval (QTc ≥460 ms) • Short QT interval (<320 ms) • Ventricular pre-excitation • Short PR interval (≤90 ms) • ST segment depression • Pathologic Q waves • Complete LBBB • Profound non-specific IVCD • Brugada pattern • Mobitz type II 2° degree AV block • 3° AV block • Atrial tachyarrhythmias • PVC or ventricular arrhythmias	Further evaluation required.
AV, atrioventricular; BPM, beats per minute; ECG, electrocardiogram; HR, heart rate; IVCD, intraventricular conduction delay; LBBB, left bundle branch block; ms, milliseconds; PVC, premature ventricular complex; RBBB, right bundle branch block; SCD, sudden cardiac death. (Pieles et al., 2026)		

DISCUSSION

All this assessment is due to prevent sports related injuries, in a study in Italy, it is found that competitive sports activity enhances the risk of sudden death in adolescents and young adults by 2.5-fold (Corrado et al., 2003). So, the most important reason to evaluate athletes is to prevent SCA which eventually leads to sudden cardiac death (SCD). For SCD reported incidence varies from 0.2 to 6.8 cases per 100,000 athletes-years. Some risk factors are increasing the risk of SCA which includes male gender, black ethnicity, older age and certain sports (football, basketball, American football, and cycling.) The underlying pathology for SCD risk varies with age in master athletes (>35 years) coronary artery disease is a more prevalent cause whereas in younger athletes' cardiomyopathies and congenital heart defects are more common (Graziano et al., 2025).

Increased amount of exercise is not a direct cause of mortality but acts like a trigger, if the athlete has an underlying pathology for arrhythmia (Corrado et al., 2005). Different underlying pathologies have been identified, and the most prevalent ones are idiopathic left ventricular hypertrophy and idiopathic left ventricular fibrosis. Inside these pathologies the most common identifiable cause of exercise induced SCD is non-ischemic left ventricular scar (NILVS) which causes sustained ventricular tachycardia (VT) (Graziano et al., 2025). In a study based on pre-participation cardiovascular evaluation of 33.735 (<35 years) athletes the most frequent disqualifying conditions were rhythm and conduction abnormalities (38.3%); hypertension (27%); valvular diseases including mitral valve prolapse complicated by significant ventricular arrhythmias, or mitral valve regurgitation, or both (21.4%); and HCM (3.6%) (Corrado et al., 1998). HCM is responsible for 40% of athletic field deaths in the USA, and up to 95% of patients with HCM can be detected with ECG (Corrado et al., 2005). A study found out 90% reduction in SCD among young competitive athletes after the implementation of the program, while rates in unscreened individuals were stable (Corrado et al.,2006).

Last line of defense: Automated External Defibrillators (AEDs)

Some lethal disorders may not be detectable by preparticipation assessment and remain clinically silent. Secondary prevention for SCD also needs to be widespread. Which includes automated external defibrillators (AEDs) and cardiopulmonary resuscitation (CPR) training in sports areas. Positive outcomes have been reported, in US there was 70% reduction in SCD rates and in Italy "Balduzzi law" increased the availability of AEDs which resulted with an

increased survival rate. FIFA Sudden Death Registry reports higher survival, if an AED is present on the location of SCA (Graziano et al., 2025).

In a study in Italy a case of SCA resuscitated successfully after the event with an AED located on the site. The reason remained unexplainable even though they performed contrast-enhanced cardiac magnetic resonance imaging (MRI), coronary computed tomography (CT), electrophysiological study, ECG monitoring, exercise stress test, toxicological analysis, sodium channel blocker test for Brugada syndrome and a comprehensive genetic panel for SCA associated mutations. This case emphasizes the importance of AEDs in sports related institutions and the presence of undetectable causes with even the most extensive tests (Sarto et al., 2023).

Master Athlete

In athletes >35 years, Systematic Coronary Risk Evaluation (SCORE) should be used to identify cardiovascular risk (Vessella et al., 2020). The most common underlying cause of SCA in older athletes is coronary heart disease (CAD), which differs from that in younger athletes. The fragile coronary artery plaques that cause CAD are diagnosed with coronary CT, which is not included in routine assessment. A negative exercise test result does not rule out CAD, therefore individuals at high risk for CAD may need additional coronary CT screening (Graziano et al., 2025).

Some studies suggest that long-term exercise increases the risk of atrial fibrillation, CAD, myocardial fibrosis, and ventricular arrhythmias in master athletes. In a study of 506 veteran athletes, ECG and sequential transthoracic echocardiography were performed to compare the success rate of ECG. In cases of suspicion, coronary CT, MRI, and coronary angiography were also performed. Thirteen individuals were diagnosed with conditions associated with SCA, and the diagnostic accuracy for conditions carrying a risk of SCA was found to be 0.73 according to international criteria, 0.81 according to Seattle criteria, and 0.77 according to ESC criteria (Halasz et al., 2025).

CONCLUSION

In conclusion, PME is not merely an isolated screening process aimed at preventing SCD, but a strategic mechanism that protects the overall health and performance of athletes from a holistic perspective. Adopting a multidisciplinary approach that goes beyond traditional cardiac examinations and includes nutrition, psychological state, and musculoskeletal health

enables the early detection of complex risk factors such as RED-s and ensures the safe continuation of athletes' long-term careers. Standardized current legal regulations in Türkiye and up-to-date international guidelines, these comprehensive evaluations form the cornerstone of preventive medicine in modern sports medicine, playing a critical role in establishing a sustainable and safe sports environment for athletes at all levels.

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