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PROTOCOL

Rationale and Design of the ORCCA (Outcomes Registry for Cardiac Conditions in Athletes) Study

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BACKGROUND: Clinical practice recommendations for participation in sports and exercise among young competitive athletes with cardiovascular conditions at risk for sudden death are based largely on expert consensus with a paucity of prospective outcomes data. Recent guidelines have taken a more permissive approach, using a shared decision-making model. However, the impact and outcomes of this strategy remain unknown.

METHODS: The ORCCA (Outcomes Registry for Cardiac Conditions in Athletes) study is a prospective, multicenter, longitudinal, observational cohort study designed to monitor clinical outcomes in athletes with potentially life-threatening cardiovascular conditions. The study will assess sports eligibility decision-making, exercise habits, psychosocial well-being, and long-term cardiovascular outcomes among young competitive athletes with cardiovascular conditions. Competitive athletes aged 18 to <35 years diagnosed with a confirmed cardiovascular condition or borderline finding with potential increased risk of major adverse cardiovascular events are eligible. Outcomes will be monitored for an initial 5-year follow-up period or until age 35, and metrics of psychosocial well-being and composite adverse cardiovascular events including arrhythmias, sudden cardiac arrest/sudden cardiac death, and evidence of disease progression will be compared among athletes who continue versus discontinue competitive sports participation.

CONCLUSIONS: The ORCCA study aims to assess the process and results of return to sport decision-making and to monitor major adverse cardiovascular events, exercise habits, and the psychosocial well-being among young competitive athletes diagnosed with confirmed cardiovascular conditions or borderline findings with potential increased risk of major adverse cardiovascular events. The results of this work will generate an evidence base to inform future guidelines.

Key Words: athletes ■ cardiovascular disease ■ shared decision making ■ sudden cardiac arrest

The field of sports cardiology developed to provide care for athletic individuals with confirmed or suspected cardiovascular conditions across the age spectrum and at all levels of performance.[1–3] Clinical practice recommendations for sports and exercise eligibility in athletes with cardiovascular conditions have been developed by major societies, including the American Heart Association, American College of Cardiology, and the European Society of Cardiology.[2,3] Although these recommendations, and subsequently clinical practice, have evolved with time to reflect more contemporary management approaches in situations of clinical uncertainty (ie, shared decision-making), the evidence base underpinning these recommendations

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Nonstandard Abbreviations and Acronyms

ORCCA	Outcomes Registry for Cardiac Conditions in Athletes
SCA	sudden cardiac arrest

is relatively sparse.[3] Recommendations, therefore, are based largely on the accumulated experience of experts in the field, and the present understanding of the natural history and corollary outcomes among competitive athletes with confirmed or suspected cardiovascular conditions remains rudimentary. To date, prospective large-scale study of active individuals with cardiovascular conditions has not been undertaken and will be required to advance the field to enable data-driven patient care.[4]

The lack of data is particularly notable for young (<35 years) competitive athletes with confirmed or suspected cardiovascular conditions. By the nature of competitive sports participation, these individuals are exposed to higher intensities and volumes of physical activity/exercise and the accompanying increased levels of physiologic stress. Sudden cardiac arrest (SCA), attributable to genetic or congenital heart disease, remains the leading cause of sudden death during sports and exercise among young competitive athletes.[5–7] The association between SCA and underlying genetic or congenital heart disease emerged from seminal autopsy studies and prompted the development of the first expert consensus guidelines in sports cardiology at the Bethesda Conference in 1985.[8] The aim of this initial document was to provide clinical recommendations regarding sports eligibility and disqualification among young competitive athletes diagnosed with cardiovascular conditions.[8] Driven largely by expert consensus and opinion surrounding the clinical significance of autopsy study results, these recommendations endorsed a strict binary "yes" or "no" clinical decision-making strategy for participation in sport based on an athlete's underlying cardiovascular diagnosis or condition.

Since the publication of these initial recommendations, several studies have suggested continued participation in competitive sport following a cardiovascular diagnosis may be permissible and associated with a limited risk of adverse events for select patients.[9–12] However, these prior studies have been limited by their retrospective nature, small size, enrollment limited to highly specialized centers, or inclusion of highly select populations with implantable cardioverter-defibrillators.[9–18] Overall, these findings along with mounting global clinical experience caring for athletes with cardiovascular conditions have resulted in 3 key observations. First, the prevalence of most "high-risk" cardiovascular conditions far exceed contemporary incidence estimates of SCA among young athletes. Second, most of the key cardiovascular conditions associated with SCA exist along a phenotypic spectrum ranging from mild, at times even uncertain or borderline expression, to overt severe pathology. Third, disqualification of young competitive athletes has important implications for long-term health and wellness.[4] In aggregate, these observations led to updated recommendations from the American Heart Association/American College of Cardiology in 2015 and European Society of Cardiology in 2022 acknowledging the clinical uncertainty in management and best practice and endorsing an individualized, patient-centered approach to sports eligibility for competitive athletes with cardiovascular conditions.[2,15,19,20] However, no definitive long-term outcomes data, derived from a prospective enrollment study, exist to support this approach and resultant impact on eligibility decisions, athlete-centered psychosocial outcomes, and adverse cardiovascular events and disease progression.

The ORCCA (Outcomes Registry for Cardiac Conditions in Athletes) study was designed to examine key outcomes among young competitive athletes with underlying cardiovascular conditions. The ORCCA study was established in May 2020 and designed and implemented in 2 distinct phases. Phase 1 focused on the evolving global COVID-19 pandemic and the concern for cardiac involvement and subsequent elevated cardiovascular risk following SARS-CoV-2 infection in young competitive athletes.[21,22] ORCCA Phase 1 enrolled 3685 athletes from 45 US colleges and universities following a confirmed diagnosis of SARS-CoV-2 infection, with several important publications.[23–27] Key findings from ORCCA Phase 1 include (1) a low prevalence of SARS-CoV-2 cardiac involvement among athletes following infection (0.5%–3%); (2) the clinical importance of cardiopulmonary symptoms, most specifically chest pain during acute infection or with subsequent "return-to-play," as a determinant of the likelihood of SARS-CoV-2 cardiac involvement; (3) a low prevalence of persistent symptoms in athletes >12 weeks (0.06%) despite a reportedly higher prevalence of postacute sequelae of SARS-CoV-2 in the general population; and (4) the determination of a reassuringly low prevalence of adverse cardiovascular events related to SARS-CoV-2 infection in >1 year of clinical surveillance following infection (0.03%; Figure 1).[25–27] The results from ORCCA Phase 1 informed the most contemporary return-to-play recommendations for athletes following SARS-CoV-2 infection.[28] ORCCA Phase 2 now aims to examine the process of sports eligibility determination and key corollary clinical and psychosocial outcomes among athletes with confirmed or suspected "high-risk" cardiovascular conditions historically associated with SCA (Figure 2). This

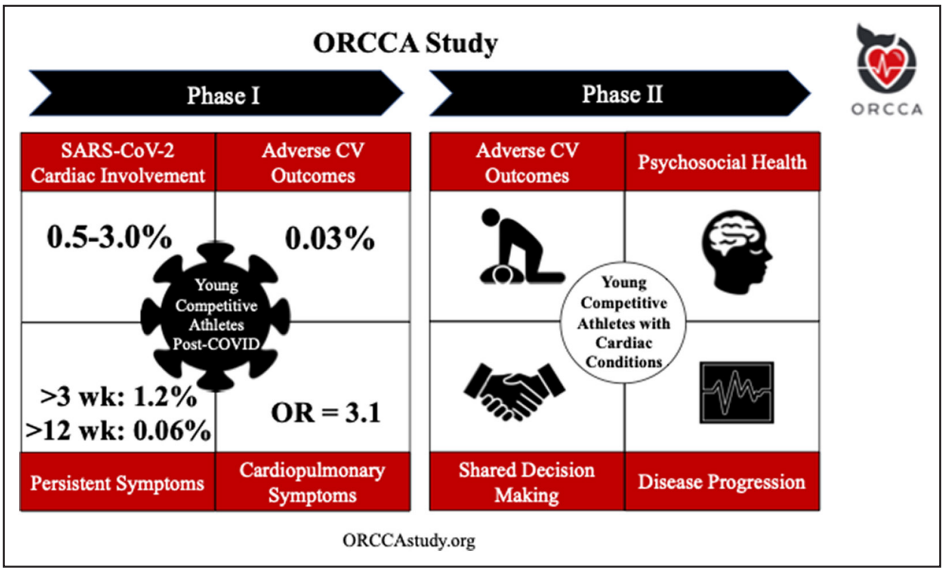

Figure 1. Overview of ORCCA phase 1 and phase 2.
Reproduced from ACC.org.[5] For Phase 1, the prevalence of SARS-CoV-2 cardiac involvement was found to be 0.5% to 3.0%.[25] On a median follow-up of >1 year (n=3675), there was 1 adverse event (0.03%) possibly related to SARS-CoV-2 infection.[26] The prevalence of persistent symptoms following SARS-CoV-2 infection >3 weeks was found to be 1.2% of athletes, and >12 weeks in 0.06% of athletes.[27] Cardiopulmonary symptoms were associated with SARS-CoV-2 cardiac involvement in multivariate analysis with odds ratio 3.1 [95% CI 1.2–7.7].[25] CV indicates cardiovascular; OR, odds ratio; and ORCCA, Outcomes Registry for Cardiac Conditions in Athletes.

paper details the study protocol for ORCCA (Phase 2) moving forward.

METHODS

The authors will make the data, methods used in analysis, and materials used to conduct the research for this study available on reasonable request. The ORCCA study is a prospective, multicenter, longitudinal, and observational cohort investigation of young competitive athletes diagnosed with pathologic cardiovascular conditions or borderline findings with potential increased risk of major adverse cardiovascular events (MACE). This study will enroll participants initiated by either a provider referral to a study portal (www.ORCCAstudy.org) or direct on-site consent and enrollment at one of the primary study sites with direct patient follow-up by a study team member. Study participants will undergo follow-up on a semiannual basis to assess for the development of prespecified study end points for a minimum of 5 years (or until age 35) with plans for ongoing longitudinal follow-up after this point. The study is approved by the Human Subjects Division at the University of Washington (STUDY00015121).

Study Aims

The primary aim of the study is to assess cardiovascular outcomes in young competitive athletes with cardiovascular conditions with potential increased risk of MACE who elect to continue or discontinue participation in organized sport. Secondary aims include assessment of (1) the process and outcome of competitive sport eligibility decisions in young competitive athletes diagnosed with cardiovascular conditions; (2) physical activity and exercise habits, volume, and intensity; (3) psychological impacts including depression, anxiety, and quality of life of living with a cardiovascular condition; (4) rates and magnitude of disease progression; and (5) changes to or implementation of a specific emergency action plan including personnel training and automated external defibrillator availability.

Study Cohort, Inclusion Criteria, and Exclusion Criteria

The study cohort will include young competitive athletes ages 18 to <35 who are diagnosed with a pathologic cardiovascular condition or borderline finding with potential increased risk of MACE (Table 1, Figure 2). This diagnosis may occur at any point throughout their lifespan. A competitive athlete is defined as an individual involved in regular training in an organized team or individual sport with an emphasis on competition and performance.[7] Athletes must be participating in competitive sport at the collegiate, semiprofessional, professional, elite, or national level at the time of enrollment or within the last 2 years. Athletes with a qualifying cardiac diagnosis who return to sport, stop voluntarily, or are excluded from sport are eligible.

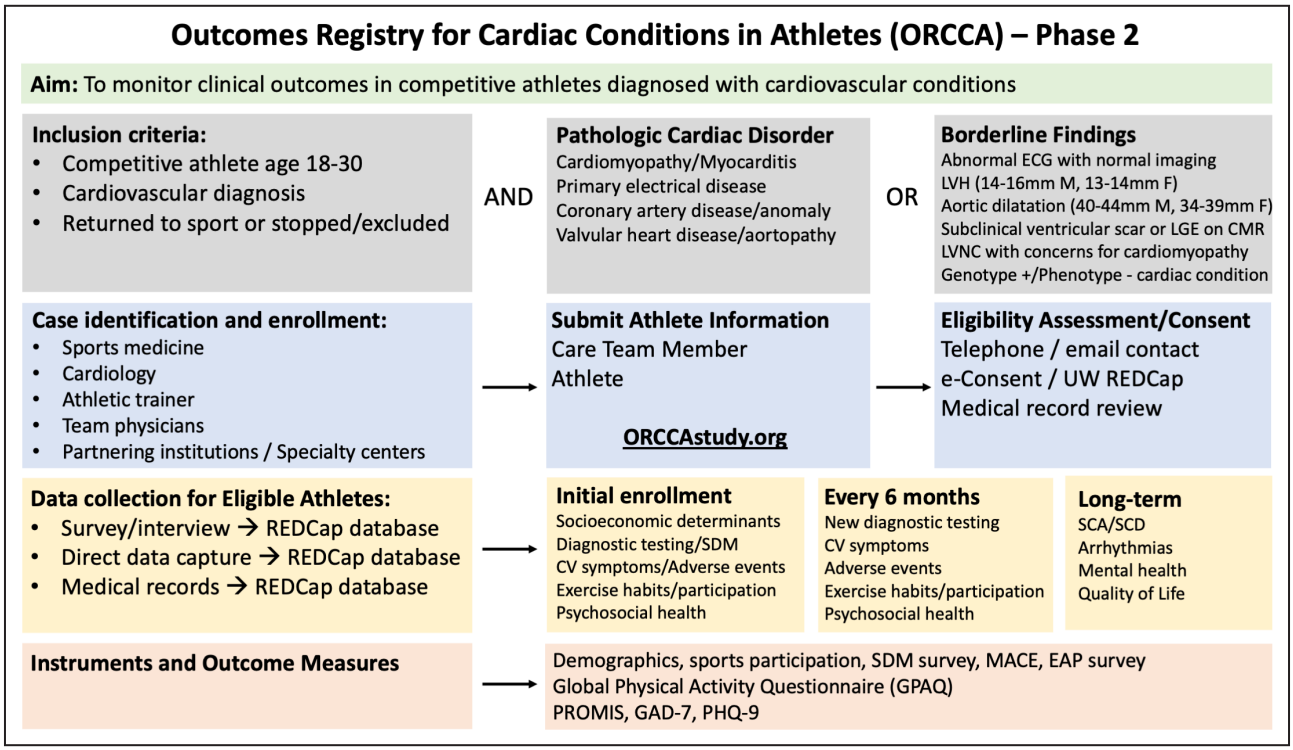

Figure 2. An overview of consent, data collection, and follow-up for ORCCA phase 2.
CMR indicates cardiac magnetic resonance imaging; CV, cardiovascular; EAP, emergency action plan; F, female; GAD-7, General Anxiety Disorder-7; LGE, late gadolinium enhancement; LVH, left ventricular hypertrophy; LVNC, left ventricular noncompaction; M, male; MACE, major adverse cardiac events; ORCCA, Outcomes Registry for Cardiac Conditions in Athletes; PHQ-9, Patient Health Questionnaire-9; PROMIS, Patient-Reported Outcomes Measurement Information System; SCA, sudden cardiac arrest; SCD, sudden cardiac death; SDM, shared decision making; and UW, University of Washington.

Pathologic cardiac conditions of interest include (1) cardiomyopathy, (2) primary electrical disease including both genetic (the cardiac channelopathies) and nongenetic causes (Wolff-Parkinson-White syndrome) and unexplained sudden cardiac arrest, (3) myocarditis, (4) coronary artery disease or anomaly, (5) congenital heart disease, (6) significant valvular heart disease, and (7) aortopathy (please see Table 1 for complete inclusion criteria).

Borderline findings with potential increased risk of MACE include (1) markedly abnormal 12-lead ECG as per the international criteria[29] with normal cardiac imaging, (2) isolated left ventricular hypertrophy (14–16 mm male, 13–14 mm female) in the absence of corollary findings confirming pathologic myopathy, (3) isolated aortic dilatation (40–44 mm men, 34–39 mm women), (4) subclinical ventricular scar or late-gadolinium enhancement on cardiac magnetic resonance imaging, (5) hypertrabeculated or noncompacted left ventricular myocardium with concerns for underlying cardiomyopathy, (6) genotype positive/phenotype negative for known pathogenic variant of genetic cardiomyopathy or channelopathy, (7) unexplained reduction in resting left ventricular ejection fraction, and (8) clinically significant premature ventricular contractions.[29,30]

Athletes with cardiovascular conditions outlined in the inclusion criteria, but who have undergone procedural treatment, including "curative" procedures such as cardiac ablation (eg, accessory pathway modification) and valvular replacement, or the placement of internal cardiac devices such as a permanent pacemaker or implantable cardioverter-defibrillator, are also eligible for enrollment. Importantly, this study is not designed to affect clinical management, nor the sports eligibility decision-making process and will enroll both athletes who stop competitive sports and those who continue competitive sports. Athletes with minor cardiovascular conditions not outlined in the inclusion criteria will not be eligible for enrollment. Athletes unable or unwilling to provide informed consent will be excluded from participation. A complete list of study definitions is outlined in Table 2.

Study Procedures

Athletes with an eligible cardiovascular condition will be recruited through a care team member, including athletic trainers, sports medicine physicians, and cardiologists (Figure 2).

The study is supported by both a steering committee and a collaborator group composed of sports

Table 1. Inclusion Criteria for ORCCA

Competitive athletes ages 18 to <35 years old* diagnosed with 1 of the following:

- *Pathologic cardiovascular condition*
  - Cardiomyopathy
  - Primary electrical disease including the cardiac channelopathies or unexplained sudden cardiac arrest
  - Myocarditis
  - Coronary artery disease/anomaly
  - Congenital heart disease†
  - Valvular heart disease‡
  - Aortopathy
- *Borderline findings with potential risk for major adverse cardiovascular events*
  - Markedly abnormal ECG§ per the international criteria with normal cardiac imaging‖
  - Isolated left ventricular hypertrophy (14–16 mm M, 13–14 mm F)
  - Isolated aortic dilatation (40–44 mm M, 34–39 mm F)
  - Subclinical ventricular scar or late gadolinium enhancement on cardiac magnetic resonance¶
  - Noncompacted left ventricular myocardium with concerns for underlying cardiomyopathy
  - Genotype positive/phenotype negative for known pathologic variant of genetic cardiomyopathy or channelopathy
  - Unexplained reduction in resting left ventricular ejection fraction (45%–50%)#

Clinically significant PVCs**

ASD indicates atrial septal defect; F, women; M, men; ORCCA, Outcomes Registry for Cardiac Conditions in Athletes; PVC, premature ventricular contraction; and VSD, ventricular septal defect.

*A competitive athlete is any athlete competing at the collegiate, semiprofessional, professional, elite, or national level.

†Moderate or greater complexity of adult congenital heart disease per the 2018 American College of Cardiology/American Heart Association Adult Congenital Heart Disease Guidelines (excludes isolated small ASD/VSD, patent foramen ovale, repaired ASD/VSD without residual shunt, repaired patent ductus arteriosus).

‡Primary structural abnormality (bicuspid, prolapse, myxomatous, congenital, or rheumatic) with moderate or greater regurgitation/stenosis or other associated abnormality (ie, bicuspid aortic valve with aortopathy or mitral valve prolapse with mitral annular disjunction).

§ie, inferolateral T-wave inversion.

‖Normal echocardiogram or cardiac magnetic resonance imaging.

¶Excluding isolated right ventricular insertion point late gadolinium enhancement and isolated papillary muscle fibrosis.

#Left ventricular ejection fraction as defined on transthoracic echocardiogram and in athletes not participating in an endurance or high-dynamic team sport.

**Frequent PVCs requiring clinical follow-up consisting of either (1) >2000 in 24 hours of nonoutflow tract or nonfascicular morphology/origin, or (2) >10 000 in 24 hours of outflow tract or fascicular morphology/origin.

cardiologists, genetic cardiologists, sports medicine physicians, and athletic trainers to help drive case enrollment. Eligible athletes may also request to enroll directly after becoming aware of the study through peers, parents, social media, or other promotion. Initial contact with eligible participants will occur through an online enrollment portal (https://orccastudy.org). Once initial contact is made through the online portal, potential participants will be provided with further information via email, text messaging, phone, or videoconferencing to discuss enrollment and study eligibility. Potential participants will be reviewed for study eligibility by the central study team. Cardiovascular diagnoses will be adjudicated by an adjudication committee consisting of clinician investigators from the study team. Each diagnosis will be evaluated

Table 2. Study Definitions

Outcome	Definition
Major adverse cardiovascular event	Sudden cardiac death, sudden cardiac arrest with successful resuscitation, ICD shock, incident heart failure, incident sustained ventricular arrhythmia, hospitalization due to cardiovascular condition, or cardiac syncope
Therapeutic intervention	Secondary ICD placement, cardiac surgery, percutaneous intervention, cardiac ablation, left cardiac sympathetic denervation, or other pharmacological treatment intensification with change/addition of medications
Sudden cardiac death	Sudden unexpected death due to a cardiac cause or a sudden death in a structurally normal heart with no other explanation for death and a history consistent with cardiac-related death
Sudden cardiac arrest with successful resuscitation	Sudden unexpected collapse due to a cardiac cause in which cardiopulmonary resuscitation or defibrillation was provided in an individual who survived
Competitive athlete	An individual involved in regular training in an organized team or individual sport with an emphasis on competition and performance
ICD implantation	Patient undergoes placement of intravenous or subcutaneous ICD
ICD shock—appropriate	A shock is delivered for confirmed ventricular arrhythmia (ventricular tachycardia or ventricular fibrillation)
ICD shock—inappropriate	A shock is delivered for any rhythm other than ventricular tachycardia/fibrillation, including sinus rhythm (usually in the setting of oversensing)
Incident heart failure	A new clinical diagnosis of heart failure
Incident sustained ventricular arrhythmia	A new clinical diagnosis of a sustained (>30 seconds or requiring therapeutic intervention for hemodynamic instability or severe symptoms) ventricular arrhythmia
Incident other clinically significant arrhythmia	Defined as one or more of the following (1) nonsustained ventricular tachycardia (≥3 beats at >100 bpm), (2) atrial fibrillation/flutter, or (3) symptomatic supraventricular tachycardia
Hospitalization due to cardiovascular condition	Admission to hospital with a primary discharge diagnosis related to cardiovascular condition. Excludes emergency department visits without admission.
Cardiac syncope	Syncope caused by an arrhythmia, blood flow obstruction, or vascular dissection typically occurring without warning or prodromal symptoms, and not neurally mediated in origin.
Cardiac surgery	Any surgical intervention on the heart or great vessels
Percutaneous intervention	Primary balloon angioplasty with or without placement of a coronary stent
Cardiac ablation	Any ablation to the atria or ventricles performed for cessation of atrial or ventricular arrhythmia
Incident diagnosis of depression	Patient Health Questionnaire-9 score ≥5 consistent with at least mild depression
Incident diagnosis of anxiety	General Anxiety Disorder-7 score ≥5 consistent with at least mild anxiety
Primary electrical disease	Inherited genetic abnormalities of the cell ionic and electrical functions or electrical system structural abnormalities leading to an increased risk for cardiac arrhythmias and sudden cardiac death

(*Continued*)

Table 2. Continued

Outcome	Definition
Aortopathy	Known inherited diagnosis at risk for aortic dissection (eg, Marfan Loeys-Dietz) or absolute aortic dimension ≥45 mm in men or ≥40 mm in women
Invasive diagnostic cardiac procedures	Coronary angiogram, right or left heart catheterization, electrophysiological study, implantable loop-recorder insertion, endomyocardial biopsy, or pericardiocentesis
Significant procedure related complication	Any complication from a diagnostic or therapeutic cardiovascular procedure considered more than minor (ie, resulting in requirement for further intervention, hospitalization or increased length of hospital stay, permanent disability, or death).

bpm indicates beats per minute; and ICD, implantable cardioverter-defibrillator.

by 2 separate reviewers and if disagreement exists, a third reviewer will assist with final consensus on study eligibility. The total number of athletes referred to ORCCA will be tracked, including athletes who ultimately enroll and do not enroll in the study.

If a participant meets the inclusion criteria and is willing to participate, further detailed informed consent for study participation and release of medical records will be obtained electronically. Medical records to be requested include reports of all screening, diagnostic, and risk-stratification clinical testing (eg, ECGs, cardiac imaging, exercise testing, ambulatory monitoring, and genetic testing), and clinical encounters (eg, preparticipation evaluations, shared decision-making and risk counseling visits, and cardiology consultations). Diagnostic cardiovascular imaging files will be requested for the development of an imaging core laboratory (See Future Directions section). Baseline evaluations will include (1) basic demographic information, including family history, including age, sex, ethnicity or race, and primary sport; (2) diagnosis and current management; (3) presence of cardiovascular symptoms; (4) history of adverse cardiovascular events; (5) aspects of the medical decision-making process; (6) sports participation; (7) exercise habits; (8) psychosocial well-being; and (9) current local emergency action plan. This information will be collected through a review of acquired medical records, online questionnaires through REDCap, and self-reported interview data.

Questionnaires include the use of standardized assessments such as the Global Physical Activity Questionnaire section on recreational activities, Patient-Reported Outcomes Measurement short form (v1.1-Global Health), General Anxiety Disorder-7, and Patient Health Questionnaire.[31–33] If an athlete submits a "red-flag" response to a mental health question (eg, suicidal ideation), an automated system alert will notify study principal investigators and the research coordinator by email, and the athlete will receive an immediate notification with information about mental health resources (eg, information for the National Suicide Prevention Lifeline and Crisis Text Line). The athlete will also be contacted within 24 to 48 hours by a study investigator to ensure proper medical evaluation or referral is performed as needed.

Follow-up evaluations will occur every 6 months to update participant information since the last assessment including (1) new clinical results, (2) new adverse cardiovascular events, (3) new cardiovascular symptoms, (4) changes in sports participation status, (5) current exercise habits, and (6) repeat psychosocial surveys (Patient-Reported Outcomes Measurement Information System, General Anxiety Disorder-7, and Patient Health Questionnaire-9). New adverse cardiovascular events will be adjudicated by an adjudication committee consisting of clinician investigators from the study team. Each event will be evaluated by 2 separate reviewers and if disagreement exists, a third reviewer will assist with final consensus. Participant data and study questionnaires are collected and stored in a REDCap database hosted at the University of Washington. Participants receive USD$100 for completing all surveys at the initial enrollment and USD$50 for completing all surveys at each 6-month follow-up. The study flow chart is presented in Figure 2.

Primary and Secondary Outcomes

The primary outcome in this study is the prevalence of adverse cardiovascular events in young competitive athletes with a confirmed high-risk cardiovascular condition or a borderline finding with potential increased risk of MACE. Adverse cardiovascular events are defined as the presence of either (1) a MACE or (2) a disease-specific therapeutic intervention. MACE will be defined as any of the following: (1) sudden cardiac death, (2) sudden cardiac arrest with successful resuscitation, (3) incident heart failure, (4) incident sustained ventricular arrhythmia, (5) hospitalization due to cardiovascular condition, (6) implantable cardioverter-defibrillator shock (appropriate or inappropriate), or (7) cardiac syncope (not clearly neurally mediated). Therapeutic intervention will be defined as the occurrence of any of the following: (1) secondary implantable cardioverter-defibrillator placement, (2) cardiac surgery, (3) percutaneous intervention, (4) cardiac ablation, (5) left cardiac sympathetic denervation, or (6) treatment intensification with change in medications.

Secondary outcomes include (1) prevalence and components of a shared decision-making process culminating in an eligibility decision following a suspected or confirmed high-risk cardiac diagnosis, (2) exercise volume and intensity, (3) incident diagnoses of depression or anxiety as suggested by validated questionnaire (Patient Health Questionnaire-9,

General Anxiety Disorder-7) scoring or local provider diagnosis, (4) prevalence and trajectory of depressive and anxiety symptoms following diagnosis (Patient Health Questionnaire-9, General Anxiety Disorder-7), (5) assessment and trajectory of quality of life (Patient-Reported Outcomes Measurement), (6) the effect of a new cardiovascular diagnosis on an institution's emergency action plan, (7) invasive diagnostic cardiac procedures, (8) significant procedure-related complications, and (9) all-cause mortality.

Statistical Analysis

Baseline and follow-up demographic data will be described using standard descriptive statistics including frequency distributions, means and SDs, and medians and interquartile ranges. Cumulative incidence for all adverse cardiovascular events collectively and specific events such as SCA will be calculated and presented as Kaplan–Meier time-to-event-curves and compared in athletes who continued versus discontinued competitive sports participation using log-rank tests. These analyses will be stratified by the underlying risk of the specific cardiovascular conditions. Generalized linear mixed effects models and frailty models, with random effects for participants and enrollment site, will be used to further assess associations between demographic and clinical variables with the occurrence of adverse cardiovascular events throughout the follow-up period. Similar models will be built to assess associations with secondary outcomes.

Given the limitations of prior outcomes studies in the young competitive athlete population, along with the heterogeneity of the cardiovascular conditions for athletes enrolled in this study, a meaningful power calculation could not be performed with appropriate confidence.

DISCUSSION

The ORCCA study is a prospective, multicenter, longitudinal, and observational study of young competitive athletes with pathologic cardiovascular conditions or borderline findings with potential increased risk of MACE. In addition to the longitudinal investigation of adverse cardiovascular events, the effect of a cardiovascular diagnosis on continued sports participation, exercise habits, psychosocial well-being, and overall quality of life will be assessed. The presence and components of a shared decision-making process preceding a sports participation decision is a key secondary focus. To our knowledge, this is the largest and most comprehensive prospective study of young competitive athletes with confirmed or suspected high-risk cardiac conditions. This study will aim to provide important prospective outcomes data to improve our understanding of the natural history, risk factors, and management of young competitive athletes with pathologic cardiovascular conditions or borderline findings with potential increased risk of MACE. Importantly, ORCCA is not designed to dictate or influence individualized management or clinical decision-making among enrolled participants, as we acknowledge the contemporary spectrum of this process in clinical practice, which ranges from paternalism to shared decision-making. The ORCCA study began active enrollment on July 1, 2022 and is ongoing. Study results will be communicated through conference presentations and peer-reviewed publications.

Future Directions

Subsequent phases of the study include international expansion, the creation of cardiac core interpretation laboratories for both imaging data and electrocardiographic data in young competitive athletes, the inclusion of an athlete control population, and the development and study of psychosocial and mental health interventions for young competitive athletes diagnosed with cardiovascular conditions. The principal aims of a core imaging laboratory will be (1) to assess disease progression in young competitive athletes comparing those who continue to participate in competitive sport to those who elect to discontinue competitive sport, (2) to compare imaging findings from young competitive athletes to control populations with cardiovascular conditions, and (3) to assess the accuracy of local provider imaging interpretation when assessed through blinded review from core laboratory imaging experts. Planned mental health interventions include the creation of educational resources on diagnoses and the formation of social support groups for athletes with cardiac diagnoses.

Limitations

This study has multiple limitations that warrant discussion. First, there is a potential for selection bias inherent in the study design as athletes will be referred through local care teams. This may lead to unequal recruitment from high-volume sports cardiology clinics and from practitioners who maintain a specific management paradigm. All attempts will be made to limit this selection bias through broad recruitment strategies, including athlete self-identification and study promotion. Moreover, all statistical models will assess for potential trends and correlations within clinics and account for these associations as necessary. The total number of athletes referred to ORCCA also will be tracked including athletes who elect to enroll and those who do not. Second, the study requires semiannual follow-up so there may be incomplete data in athletes who are lost to follow-up. Multiple reminder strategies and participant incentives will be implemented to minimize this participant attrition.

Third, athletes who have been misdiagnosed with a cardiovascular condition could bias outcome results. Specifically, secondary sources for diagnostic information, particularly cardiovascular imaging reports without study investigator imaging review and confirmation, may lead to enrollment of athletes without significant pathology meeting study inclusion criteria. Longitudinal observation with repeated follow-up imaging studies will help mitigate this source of error, and the future planned development of an imaging core laboratory will allow for retrospective and eventual prospective review of report accuracy. Lastly, recall bias pertaining particularly to prediagnosis variables such as cardiovascular symptoms and exercise volumes may exist.

CONCLUSIONS

A critical need exists for cardiovascular outcomes data in athletes with suspected or high-risk cardiovascular conditions as contemporary sports cardiology guidelines are based predominantly on expert opinion. The ORCCA study is a prospective multicenter, longitudinal, and observational investigation with the primary aim to assess adverse cardiovascular events among competitive athletes with underlying cardiovascular conditions. Key secondary aims include the assessment of the process of competitive sport eligibility decisions, the psychosocial and lifestyle impacts of a new cardiovascular diagnosis, and the rate and magnitude of disease progression.

ARTICLE INFORMATION

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