

Cardiovascular health in master athletes engaged in competitive sport

Esporte competitivo e saúde cardiovascular de atletas master

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Abstract

Introduction: Aging is naturally accompanied by a decline in overall health. Regular physical activity, whether amateur or competitive, is recognized as a key strategy to promote health and well-being in older adults. However, many individuals begin exercising without prior cardiovascular assessment. **Objective:** This systematic review aimed to assess the prevalence and types of cardiovascular diseases in master athletes. **Methods:** Observational studies published within the last ten years were included if they evaluated cardiovascular outcomes or diseases in master athletes (aged >35 years) participating in any sport. Studies were excluded if they lacked data on predefined cardiovascular outcomes, focused solely on rehabilitation or training interventions, failed to identify the sport involved, were not available in full, or were letters to editors, commentaries, or unpublished manuscripts. The literature search strategy used the following keywords: "cardiovascular outcomes," "cardiac outcomes," "cardiovascular diseases," "cardiac outcomes" and "master athletes." **Results:** Ten studies were included, most involving master endurance athletes aged 35 to 90 years. Seven studies included both sexes, two included only men, and one did not specify sex. Reported outcomes included atrial fibrillation (n = 2), arrhythmia (n = 2), myocardial fibrosis (n = 1), ventricular dysfunction (n = 1), and atherosclerotic disease (n = 5). Of the ten studies, eight reported that master athletes have a higher propensity to develop cardiovascular disease, while two found no such association. **Conclusion:** Master athletes may face an increased risk of cardiovascular disease. These findings highlight the importance of thorough cardiovascular screening before engaging in competitive sports at older ages.

Keywords: Cardiovascular diseases. Physical activity. Aging.

Resumo

Introdução: *O envelhecimento é associado ao declínio da saúde. A atividade física e a prática de esporte amador ou competitivo vêm com o intuito de agregar na saúde destes indivíduos, porém muitos iniciam a atividade física sem conhecimento prévio de sua condição cardiovascular.* ***Objetivo:*** *Compreender as doenças cardiovasculares em atletas master.* ***Métodos:*** *Trata-se de uma revisão sistemática de estudos observacionais que investigaram desfechos/doenças cardiovasculares em atletas master (acima de 35 anos), praticantes de qualquer modalidade esportiva nos últimos dez anos. Foram excluídos estudos que não destacaram os desfechos-alvos do trabalho, que abrangeram reabilitações ou treinamentos, que não delimitaram os esportes praticados, cartas ao revisor ou comentários, manuscritos não publicados e aqueles não disponíveis na íntegra. As palavras-chave de busca foram "cardiovascular outcomes" ou "cardiac outcomes" ou "cardiovascular diseases" ou "cardiac outcomes" e "master athletes".* ***Resultados:*** *Foram avaliados dez estudos, com predominância de atletas master de endurance com idade entre 35 e 90 anos. Sete estudos avaliaram homens e mulheres, dois estudos avaliaram somente homens e um estudo não mencionou a informação. Quanto aos desfechos, os resultados incluíram fibrilação atrial (n = 2), arritmias (n = 2), fibrose miocárdica (n = 1), disfunção ventricular (n = 1) e doenças ateroscleróticas (n = 5). Dos dez artigos avaliados, somente dois não identificaram maior risco cardiovascular em atletas master. Os demais estudos apontaram que atletas master têm maior propensão a desenvolver doenças cardiovasculares.* ***Conclusão:*** *Esta revisão traz indícios de que atletas master apresentam risco cardiovascular, sendo necessária, portanto, a triagem detalhada sobre condições cardiovasculares anteriormente à prática esportiva.*

Palavras-chave: *Doenças cardiovasculares. Atividade física. Envelhecimento.*

Introduction

Aging is typically characterized by a progressive physiological decline that compromises functional capacity, independence, and quality of life. It increases susceptibility to chronic diseases, promotes sarcopenia, and leads to greater reliance on healthcare services.[1] Even in the absence of diagnosed conditions such as systemic arterial hypertension (SAH) or cardiovascular diseases (CVD), structural and functional changes occur in the cardiovascular system over time, ultimately compromising cardiac reserve. These age-related changes lower the threshold for the development of three key cardiac conditions: ventricular hypertrophy, chronic heart failure (CHF), and atrial fibrillation (AF), all of which become more prevalent with advancing age. Cardiac aging also involves myocyte loss, compensatory hypertrophy, and reduced responsiveness to sympathetic stimuli, which together impair myocardial contractility and cardiac output.[2]

Another hallmark of aging is oxidative stress, driven by an imbalance between oxidant and antioxidant compounds that favors the excessive production of free radicals. Prolonged oxidative stress is implicated in the etiology of numerous conditions, such as atherosclerosis, diabetes mellitus, obesity, neurodegenerative disorders, cancer, and cardiovascular disorders.[3] Studies indicate that this phenomenon is also associated with aging.[4,5]

Despite these physiological declines, master athletes defy the stereotypes of frailty and functional decline often associated with aging. The prevalence of chronic diseases or disabilities is significantly lower among this population, even in individuals aged 70 years and older.[6]

The age at which an athlete is considered a "master" or "veteran" varies by sport: from 25 years old in swimming[7] and 35 years in athletics.[8-11] Notably, cardiovascular problems tend to become a major cause of morbidity from the age of 35 onwards.[10,11] Master athletes are typically defined as individuals engaged in competitive individual or team sports that emphasize performance and involve regular, structured training. Master sports enable older individuals to regularly compete against others in the same age category across a wide variety of disciplines. Competitions range from local monthly events to large-scale national and international championships held every two to four years.[12]

Events organized and marketed exclusively for master athletes have increased in number and popularity in recent years.[13] The master athlete population is highly heterogeneous, including former professionals who have maintained long-term training regimens, as well as previously sedentary individuals who adopt competitive exercise later in life – sometimes abruptly.[14]

Regular moderate physical activity is well established as a protective factor against all-cause mortality and a promoter of long-term cardiovascular health.[15] Current guidelines recommend 150 minutes of moderate or 75 minutes of vigorous aerobic activity per week for adults to achieve substantial health benefits,[16] including those with chronic conditions such as type 2 diabetes mellitus and SAH (150–300 minutes of moderate or 75–150 minutes of vigorous exercise per week). Additional benefits are also gained from muscle-strengthening exercises performed at least two to three times a week.[17]

However, the well-known and documented cardiovascular benefits of physical exercise must be weighed against its potential risks, particularly in athletes over the age of 35 – 40 years.[15] These individuals have a high risk of sport-related acute cardiovascular events, including sudden death (SD), primarily due to underlying atherosclerotic coronary artery disease (CAD).[18] Furthermore, approximately 50% of patients who experience acute myocardial infarction (AMI) or sudden cardiac arrest have no prior symptoms or known history of CAD.[16]

Recently, concerns regarding the potential cardiovascular risks of excessive endurance exercise have recently gained considerable attention from the media and scientific community. Endurance sports, defined by sustained aerobic effort, have been linked to early-onset AF, increased coronary artery calcification (CAC), and unexplained myocardial fibrosis.[16]

Thus, to ensure safe participation in competitive sports that demand high exertion, identifying individuals at risk is essential.[19] Several risk stratification algorithms have been developed for this purpose. Current recommendations for pre-participation cardiovascular assessment in adults incorporate traditional risk factors such as age, sex, blood pressure, cholesterol levels, and smoking history,[18] as well as self-reported questionnaires and diagnostic tools including resting and exercise electrocardiograms (ECGs). Notably, European and American guidelines differ on several points. However, some authors argue that large-scale screening of master athletes is not warranted, even for high-intensity endurance events such as marathons.[15]

According to Abbatemarco et al.,[20] in the United States, only 24.6 – 51.5% of novice endurance runners (less than five years of training) undergo pre-participation screening. This is partly due to healthcare professionals referring athletes for screening only when they are older or competing in long-distance events, often neglecting established cardiovascular risk factors such as SAH, DM, hypercholesterolemia, smoking, and family history.

This has contributed to a widespread belief that athletes are relatively “immune” to cardiovascular disease However, there is an undeniable risk of adverse outcomes such as AMI, SD, and AF, particularly in asymptomatic individuals with a relevant family history. Thus, a clear knowledge gap remains in understanding the cardiovascular risks faced by master athletes. As such, this study aimed to conduct a systematic review of the literature to investigate cardiovascular diseases (e.g., atherosclerosis, arrhythmias, CHF) and related outcomes (e.g., AMI, SD, ventricular dysfunction) in master athletes.

Methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[21] and was registered in the PROSPERO database (registration number: CRD42024543042).

Search strategy

One researcher conducted the database search and exported the results into StArt software, which consolidates search results from multiple databases, identifies duplicates, and facilitates study selection and data extraction.[22]

Searches were performed in the PubMed, LILACS, SciELO, MEDLINE, Web of Science, and Cochrane databases via the CAPES Journals Portal (Figure 1). Keywords were selected based on relevant literature and the Medical Subject Headings (MeSH) thesaurus, using the following terms: “cardiovascular outcomes” OR “cardiac outcomes” OR “cardiovascular diseases” OR “cardiac diseases” AND “master athletes.” To identify additional studies, the reference lists of included articles were also manually screened. No restrictions were placed on language or access type (open or paid).

Two independent researchers screened the titles, abstracts, and keywords of all the studies identified. Potentially eligible articles were retrieved in full for further assessment and possible inclusion in the systematic review. Disagreements were resolved through discussion with a third researcher.

Inclusion and exclusion criteria

Studies were eligible if they were observational, prospective, and retrospective research that investigated cardiovascular diseases and their outcomes in master athletes (aged > 35 years), engaged in any type of sport. The cardiovascular diseases of interest were atherosclerosis, arrhythmias, and CHF. Outcomes included AMI, SD, and ventricular dysfunction. Only studies published in the past ten years (2014–2024) were included, reflecting the growing interest in performance-related cardiovascular issues in this population in the last decade.

Exclusion criteria were studies that did not report the diseases or outcomes of interest, those focused on rehabilitation or training, that did not specify the sport practiced, and were not available in full. Letters to the editor, commentaries, systematic reviews, meta-analyses, case reports, and unpublished manuscripts were also excluded.

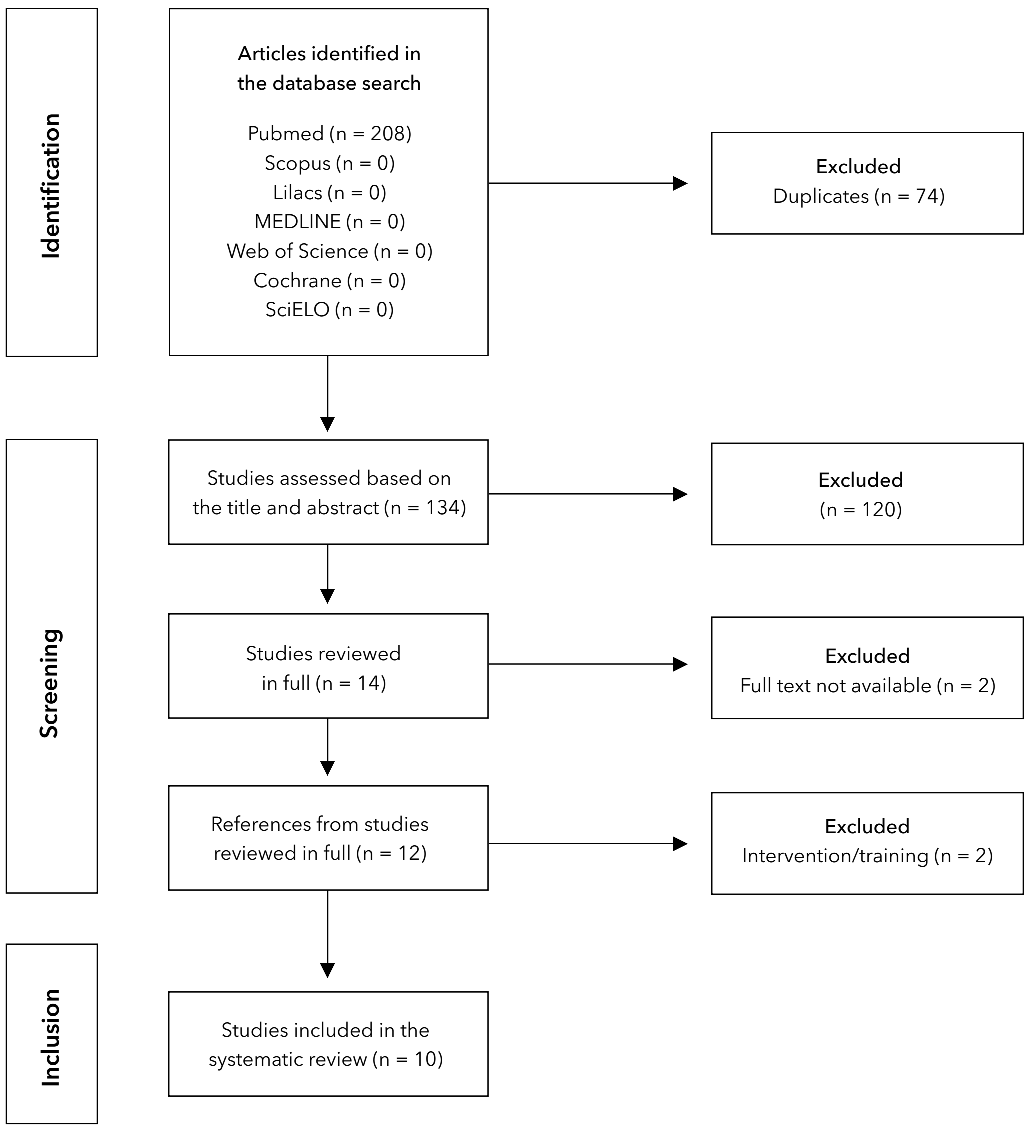

Figure 1 - Flowchart of publication selection according to inclusion criteria.

Data extraction and quality assessment

Data extraction was performed independently by two researchers and compiled into an Excel spreadsheet. The following information was extracted from each study: title, authors, year of publication, country, study design, type of sport, sample characteristics (sex and age), cardiovascular diseases/outcomes, and diagnostic instruments or examinations used (Table 1).

The methodological quality of the included studies was assessed using checklists by the Joanna Briggs Institute for cross-sectional[23] and cohort.[24] Two independent researchers conducted the assessments and disagreements were resolved through discussions with the research team. The checklists for cross-sectional studies and for cohort studies contain eight and eleven items, respectively. Each item was scored as "yes," "no," "unclear," or "not applicable." Methodological quality was rated as low (≤ 4 "yes" responses), moderate (5–6), and high (≥ 7) for cross-sectional studies; and low (≤ 5 "yes" responses), moderate (6–9), and high (≥ 10) for cohort studies.

Table 1 - Abstracts of articles included in the study

Studies	Title	Sport studied	Population	Results
Myrstad et al.[28] 2014, Norway Study design: cross-sectional	Increased risk of atrial fibrillation among elderly Norwegian men with a history of long-term endurance sport practice	Cross-country skiing	509 athletes who participated in ski racing in years prior to the survey, and 1867 controls; 65-90 years old	- The estimated risk of AF in sedentary individuals was 11.3%. - The estimated risk of AF for participants engaging in moderate physical activity was 13.0% and 17.6% for intense physical activity.
Abdullah et al.[38] 2016, USA Study design: cross-sectional	Lifelong physical activity regardless of dose is not associated with myocardial fibrosis	Participants in competitions organized by the US Masters Sports Associations (marathons and triathlons)	92 men and women (4 groups: sedentary; occasional PA practitioners; regular PA practitioners; competitive athletes); > 65 years old	- Left ventricular end-diastolic volume, end-systolic volume, and mass were higher in those with a history of higher physical activity levels. - No difference in ejection fraction. - No intergroup difference in late gadolinium enhancement (indicating no evidence of myocardial fibrosis in the participants).
Shapero et al.[31] 2016, USA Study design: cross-sectional	Cardiovascular risk and disease among masters endurance athletes: insights from the Boston MASTER (Masters Athletes Survey To Evaluate Risk) initiative	Boston Marathon Runners	591 athletes (391 men and 200 women); > 35 years old	- 64% of athletes had one or more Cardiovascular risk factors; - 9% prevalence of established cardiovascular disease; - AF was associated with years of exposure to exercise; - CAD was associated with dyslipidemia; - CAD was not associated with exposure to exercise.
Merghani et al.[30] 2017, UK Study design: cross-sectional	Prevalence of subclinical coronary artery disease in masters endurance athletes with a low atherosclerotic risk profile	Running and cycling	152 athletes (70% men), and 92 controls; > 40 years old	- Most athletes (60%) and control subjects (63%) had normal CAC scores. - Number of years of training was the only independent variable associated with a higher risk of CAC. - Male athletes were more likely to have coronary plaques compared with sedentary men with a similar.
Morrison et al.[19] 2018, Canada Study design: cross-sectional	Assessment of cardiovascular risk and preparticipation screening protocols in masters athletes: the Masters Athlete Screening Study (MASS): a cross sectional study	23 disciplines, primarily running, cycling, hockey, triathlon and rowing	798 athletes (500 men and 298 women); > 35 years old	- Cardiovascular disease was detected in 11.4%, with CAD (7.9%) being the most common diagnosis. - A high Framingham risk score (>20%) was observed in 8.5% of the study population. - Ten athletes were diagnosed with significant CAD; - 90% were asymptomatic. A high Framingham risk score was the strongest indicator of underlying CAD.

Note: AF = atrial fibrillation; CAC = coronary artery calcification; CAD = coronary artery disease; PA = physical activity.

Table 1 - Abstracts of articles included in the study (continued)

Studies	Title	Sport studied	Population	Results
Panhuyzen-Goedkoop et al.[32] 2020, Netherlands Study design: retrospective study	ECG criteria for the detection of high-risk cardiovascular conditions in master athletes	Athletes linked to the Dutch Olympic Committee	2578 athletes; > 35 years old	- Atrial enlargement (n = 109; 4.1%) and left ventricular hypertrophy (n = 98; 3.8%) were the most common abnormalities identified using the ESC-2005 or Seattle criteria. - ST-segment deviation (n = 66; 2.6%) and T-wave inversion (n = 58; 2.2%) were the most frequent findings based on the International criteria. - The ESC-2005 criteria detected a larger number of exercise-related heart conditions (n = 46; 1.8%) compared with the Seattle (n = 36; 1.4%) and International criteria (n = 33; 1.3%). - Coronary artery disease was the most frequently identified high-risk cardiovascular condition (n = 24; 0.9%).
Cavigli et al.[34] 2020, Italy Study design: cross-sectional	The acute effects of an ultramarathon on biventricular function and ventricular arrhythmias in master athletes	Ultramarathon	68 athletes (47% men); > 40 years old	- Increased R wave amplitude in V1 and prolonged QTc interval following the ultramarathon. - 7% of athletes exhibited isolated exercise-induced premature ventricular beats. - No episodes of nonsustained ventricular tachycardia or changes in left ventricular ejection fraction, global longitudinal deformation, or torsion were observed.
German et al. [29] 2020, USA Study design: prospective cohort	Physical activity, coronary artery calcium, and cardiovascular outcomes in the Multi-Ethnic Study of Atherosclerosis (MESA)	Physical activity	6777 men and women; 45 to 84 years old	- Participants at low risk for CAC in the highest PA quartile had reduced adjusted hazard ratios for CVD and all-cause mortality compared to those in the lowest PA quartile. - Participants at high risk for CAC in the highest PA quartile also had reduced adjusted hazard ratios for all-cause mortality compared to those in the lowest PA quartile. - High PA was not associated with an increased risk of any outcomes, regardless of CAC category, sex, or race/ethnicity.
Gao et al.[35] 2020, China Study design: prospective cohort	Associations of long-term physical activity trajectories with coronary artery calcium progression and cardiovascular disease events: results from the CARDIA study	Physical activity	2497 (1120 men and 1377 women); 40.4 ± 3.6 years old	- The High PA group had a greater risk of CAC progression compared to the low PA group after adjusting for traditional cardiovascular risk factors. - High PA was not associated with an increased risk of incident cardiovascular events, and the incidence of cardiovascular events among participants with CAC progression was similar across all physical activity levels.
Bosscher et al.[36] 2023, Belgium Study design: prospective cohort	Lifelong endurance exercise and its relation with coronary atherosclerosis	Running, cycling, triathlon	176 controls, 191 late athletes, and 191 lifelong athletes; Men; 40 to 70 years old	- Prevalence of coronary plaques (calcified, mixed, and non-calcified). - The athlete group demonstrated higher peak oxygen consumption. - Lifetime endurance sports participation was associated with greater odds of having ≥1 coronary plaque (OR: 1.86, CI: 1.17–2.94), ≥1 proximal plaque (OR: 1.96, CI: 1.24–3.11), ≥1 calcified plaque (OR: 1.58, CI: 1.01–2.49), ≥1 proximal calcified plaque (OR: 2.07, CI: 1.28–3.35), ≥1 non-calcified plaque (OR: 1.95, CI: 1.12–3.40), ≥1 proximal non-calcified plaque (OR: 2.80, CI: 1.39–5.65), and ≥1 mixed plaque (OR: 1.78, CI: 1.06–2.99) compared to healthy non-athletes.

Note: CAC = coronary artery calcification; CARDIA = Coronary Artery Disease Risk Development in Young Adults; CI = confidence interval; CVD = cardiovascular disease; ECG = electrocardiogram; ESC = European Society of Cardiology; OR = odds ratios; PA = physical activity; QTc = corrected QT interval (ECG); R = R wave (ECG); ST = segment between the end of the QRS complex and the beginning of the T wave (ECG); V1 = ECG lead V1.

Results

The literature search was conducted between February and April 2024, and initially identified 208 publications across the online databases. After removing 74 duplicates, 134 records remained for screening. Based on titles and abstracts, 120 studies were excluded for not meeting the scope of the review. Of the 14 articles that met the inclusion criteria, two were excluded because the full text was not available and two for being literature reviews. Thus, ten studies were included in the final systematic review.

The ten studies included in this review represented a wide range of sports disciplines, with endurance sports being the most common among master athletes. Study designs comprised six cross-sectional, one retrospective, and three prospective cohort studies. Sample sizes varied considerably, with cohort studies involving a total of over 9,000 individuals and crosssectional assessing 68 to 798 participants. The retrospective study analyzed data from 2,578 individuals, and the prospective cohort 392 participants. Participants' ages ranged from 35 to 90 years across all studies. Seven studies included both men and women, two focused exclusively on men, and one did not report the sex of the participants. In terms of cardiovascular outcomes, AF was examined in two studies, arrhythmias in two, myocardial fibrosis in one, ventricular dysfunction in one, and atherosclerotic diseases in five (Table 1).

The methodological quality of the included studies was assessed using the JBI checklists for cross-sectional and cohort studies. As shown in Tables 2 and 3, cross-sectional study scores ranged from 4 to 7, with an average of 6, and cohort studies from 6 to 9 with an average score of 7. No study was classified as having low methodological quality.

Table 2 - Methodological quality of the cross-sectional studies included in the review

Study	1.	2.	3.	4.	5.	6.	7.	8.	9.
Myrstad et al.[28]	Yes	Yes	No	No	No	No	Yes	Yes	4/8
Abdullah et al.[38]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	6/8
Shapero et al.[31]	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	7/8
Merghani et al.[30]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	6/8
Morrison et al.[19]	Yes	Yes	No	Yes	Yes	Yes	No	Yes	6/8
Panhuyzen-Goedkoop, et al.[32]	No	No	Yes	Yes	Yes	Yes	Yes	Yes	6/8
Cavigli et al.[34]	Yes	Yes	No	Yes	No	No	Yes	Yes	5/8

Note: 1. Were the inclusion criteria for the sample clearly defined? 2. Were the study subjects and setting described in detail? 3. Was the exposure measured validly and reliably? 4. Were objective and standardized criteria used for measuring the condition? 5. Were confounders identified? 6. Were strategies for dealing with confounders stated? 7. Were the outcomes measured validly and reliably? 8. Was appropriate statistical analysis used? 9. Quality.

Table 3 - Methodological quality of the cohort studies included in the review

Study	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
German et al. [29]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	9/11
Gao et al. [35]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	8/11
Bosscher et al.[36]	No	No	Yes	Yes	Yes	Yes	Yes	N/A	N/A	N/A	Yes	6/11

Note: 1. Were the two groups similar and recruited from the same population? 2. Were exposures measured similarly to assign people to the exposed and unexposed groups? 3. Was exposure measured validly and reliably? 4. Were confounders identified? 5. Were strategies to address confounders stated? 6. Were groups/participants free of the outcome at baseline (or at time of exposure)? 7. Were outcomes measured validly and reliably? 8. Was follow-up time reported and sufficient for outcomes to occur? 9. Was follow-up complete and, if not, were reasons for loss to follow-up described and explored? 10. Were strategies used to address incomplete follow-up? 11. Was appropriate statistical analysis used? 12. Quality. N/A = not applicable.

Discussion

This systematic review aimed to identify the presence of cardiovascular diseases and related outcomes in master athletes. There is robust evidence linking regular physical activity with health promotion, providing both physiological and psychological benefits.[25] However, Brazilian literature lacks studies specifically examining cardiovascular diseases and outcomes in master athletes, a gap made more significant by two recent social trends: an aging population and the increasing "sportification" of this population – on identifying this group.[26] To address this, we reviewed the current literature on the topic. Of the ten studies analyzed, only two did not report increased cardiovascular risk among master athletes, whereas the majority indicated that this population is more susceptible to cardiovascular diseases.[27]

The Brazilian Guideline on Sports and Exercise Cardiology[27] recommends a thorough pre-participation cardiovascular assessment for individuals engaging in sports, aiming to identify risk factors and cardiovascular conditions that may contraindicate exercise or predispose to SD. This evaluation typically includes clinical history, physical examination, and screening questionnaires, supplemented by blood work, ECGs, stress tests, cardiopulmonary exercise testing, and echocardiography.

Within our review, two studies assessed cardiovascular outcomes exclusively through questionnaires;[28,29] two[19,30] combined questionnaires with complementary exams; and the remainder relied primarily on diagnostic exams. ECG was the most commonly used tool, followed by magnetic resonance imaging and computed tomography.

Several studies focused on cardiac rhythm abnormalities in master athletes. For example, Myrstad et al.[28] reported an increased risk of AF in athletes over 65 years old with a history of competitive cross-country skiing. AF was identified through questionnaires, and results showed that the estimated risk of AF was higher among participants engaging in moderate or vigorous physical activity compared to sedentary individuals. Similarly, Shapero et al.,[31] observed an association between AF and cumulative years of physical exercise, with a 9% prevalence of established CVD in master athletes.

Panhuyzen-Goedkoop et al.[32] evaluated the applicability to master athletes of ECG interpretation criteria developed for younger athletes (<35 years). Despite the elevated risk of master athletes relative to the general population, it remains unclear whether these traditional criteria adequately identify high-risk cardiovascular conditions in the older athletic population.

These findings contrast with the review by Fyyaz et al.,[33] who argued that exercise-induced arrhythmias are rare and predominantly occur in athletes with genetic predisposition. Reinforcing this notion, Cavigli et al.[34] studied 68 ultramarathon master athletes and found no evidence of exercise-induced ventricular dysfunction or significant acute arrhythmias. However, the study's limitations included data collected only before and after the race, absence of 12-lead ECGs, and the homogeneous Caucasian sample, restricting generalizability to other ethnic groups.

With respect to obstructive heart disease, Merghani et al.[30] evaluated subclinical CAD in endurance master athletes with low atherosclerotic risk profiles. While most participants had normal CAC scores, a longer history of endurance training independently correlated with higher CAC risk. The authors suggested that although this might indicate a negative effect of long-term endurance training, the calcified and stable nature of these plaques could offer protection against rupture and myocardial infarction.[30]

Morrison et al.[19] studied cardiovascular risk assessment during pre-participation screening in master athletes and emphasized that these individuals are not immune to cardiovascular risk or disease. In their sample of 798 athletes, 11.4% had diagnosed cardiovascular disease, with CAD being the most prevalent.

German et al.[29] and Gao et al.[35] explored the relationship between physical activity and cardiovascular health in two longitudinal multicenter studies, namely Multi-Ethnic Study of Atherosclerosis (MESA) and Coronary Artery Disease Risk Development in Young Adults (CARDIA), respectively. The former evaluated the association between physical activity levels (high, moderate, low) and the presence of CAC as a predictor of future cardiovascular events, and the latter investigated the long-term impact of physical activity trajectories on CAC progression and cardiovascular risk events. Both studies used CAC as a marker of cardiovascular risk. Specifically, MESA focused on the impact of current physical activity levels on CAC presence, while CARDIA followed individuals with a mean age of 40.4 ± 3.6 years to examine how the evolution of physical activity throughout life influences cardiovascular risk.

Both studies found that higher physical activity levels were not associated with an increased risk of CAC or cardiovascular events, with MESA[29] emphasizing the cardiovascular benefits of physical activity and the CARDIA study[35] indicating a similar incidence of cardiovascular events even among participants with CAC progression across all physical activity levels. Together, these studies offer a broader perspective on the relationship between physical activity and cardiovascular health. However, it is important to note that neither study specifically examined master athletes.[29,35]

Bosscher et al.[36] reported a paradoxical association between lifelong endurance exercise and coronary atherosclerosis, challenging the long-standing belief that regular exercise protects against heart disease. Lifelong endurance athletes exhibited a higher prevalence of coronary plaques — including those more prone to rupture and acute cardiac events — compared to physically active non-athletes. Although the study did not evaluate the incidence of cardiovascular events such as myocardial infarction or stroke, the presence of coronary plaques is a known predictor of these outcomes. These findings suggest that lifelong endurance athletes may have a higher-than-expected risk for serious cardiovascular events. However, Aengevaeren et al.[37] reported more stable coronary plaque profiles in endurance athletes, with a predominance of calcified plaques less prone to rupture, indicating a potentially lower risk of major cardiovascular events in this population.

With regard to cardiac structure, Abdullah et al.[38] found no evidence of myocardial fibrosis in a sample divided into four groups (sedentary, occasional exercisers, regular exercisers, and competitive athletes). Among regular competitors, corresponding to the master athletes of interest in our review, no adverse cardiac outcomes were observed. However, interpretation of these findings is limited by the small sample size of master athletes and the study's inability to account for variables such as exercise intensity, duration, or modality.[38]

An important consideration in studies involving master athletes is the distinction between individuals with a lifelong history of sports participation and those who began exercising later in life. Many studies included in this review were cross-sectional and therefore did not assess long-term exposure to physical activity. This omission may overlook morphofunctional cardiac adaptations that develop over time and could contribute to arrhythmias, reduced contractile capacity, or structural responses to ischemic events.

Moreover, the long-held belief that regular endurance exercise protects against ischemic heart disease has been increasingly questioned. Recent studies report a greater prevalence of coronary disease and atherosclerotic plaque formation among highly trained athletes compared to healthy non-athletes.[36] These findings do not support the hypothesis that highly trained endurance athletes develop more benign plaque com-positions that explain their lower cardiovascular event rates. Therefore, physical exercise should not be viewed as the sole determinant of favorable cardiovascular outcomes but rather should be integrated a broader framework of healthy lifestyle practices, including balanced nutrition, moderate alcohol consumption, and smoking cessation.

Similarly, Fruytier et al.[39] reported cases of asymptomatic master athletes who experienced adverse events during sports participation. It is well established that most sports-related deaths occur among athletes over 35 years old. While sudden cardiac events in younger athletes are typically caused by congenital, structural, or electrical cardiac disorders, CAD is the leading cause of major cardiovascular events in master athletes. As such, pre-participation assessment is essential to define clear criteria and protocols that ensure safe sports participation in this population. Event organizers should also verify that all participants, especially those over 35, are medically cleared to take part.

Our methodological assessment identified key limitations in the included studies. In the cross-sectional studies, exposure was not always measured validly or reliably, and confounding factors were not consistently addressed. In cohort studies, important aspects such as loss to follow-up and strategies for handling incomplete data were often insufficiently reported. These shortcomings should be addressed in future studies.

This review also has limitations. The number of studies included was small. Heterogeneity across samples, including differences in age, physical activity level, type of exercise, assessment instruments, and sex distribution, precluded the performance of meta-analysis, which would have strengthened the external validity of our findings. Moreover, no studies evaluated Brazilian master athletes, underscoring the need for local research to investigate their specific characteristics and

challenges, such as healthcare access and pre-participation screening. Additionally, while several studies demonstrated methodological weaknesses that limited their quality ratings, most attempted to minimize bias.

Despite these limitations, this review provides important insights into cardiovascular risk and outcomes in master athletes and underscores the value of systematic health evaluation and monitoring by professionals.

Conclusion

This review provides evidence that master athletes may face increased risk for cardiovascular disease. As such, these findings reinforce the need for comprehensive cardiovascular screening before participation in recreational or competitive sports. This preventive approach may help reduce the incidence of sudden cardiac death and guide healthcare providers and high-performance trainers and coaches in safely managing this population.

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Authors' contributions

TMR, JHA, and CBFP conceived and designed the study; TMR, JCS, MBR, and CS carried out the investigation; TMR, JCS, and JCMM performed the data analysis; and JHA and CBFP provided supervision. All authors contributed to data interpretation, participated in drafting and reviewing the original manuscript, and approved the final version.

References

1. Tanaka H. Aging of competitive athletes. Gerontology. 2017;63(5):488-94. https://doi.org/10.1159/000477722

2. Jakovljevic DG. Physical activity and cardiovascular aging: Physiological and molecular insights. Exp Gerontol. 2018;109:67-74. https://doi.org/10.1016/j.exger.2017.05.016

3. Barbosa KBF, Costa NMB, Alfenas RCG, Paula SO, Minim VPR, Bressan J. Estresse oxidativo: conceito, implicações e fatores modulatórios. Rev Nutr. 2010;23:629-43. https://doi.org/10.1590/S1415-52732010000400013

4. Peng C, Wang X, Chen J, Jiao R, Wang L, Li YM, et al. Biology of ageing and role of dietary antioxidants. Biomed Res Int. 2014;2014:831841. https://doi.org/10.1155/2014/831841

5. Luo J, Mills K, le Cessie S, Noordam R, van Heemst D. Ageing, age-related diseases and oxidative stress: What to do next? Ageing Res Rev. 2020;57:100982. https://doi.org/10.1016/j.arr.2019.100982

6. Black D, Climstein M, Gifford J, Halar F, O'Connor H, Prvan T, et al. Prevalence of chronic conditions in masters games athletes. J Sci Med Sport. 2021;24(Suppl 1):S5-6. https://www.jsams.org/article/S1440-2440(21)00270-X/abstract

7. World Aquatics [Internet]. 2024 [cited 2024 May 6]. Available from: https://www.worldaquatics.com

8. World Athletics [Internet]. 2024 [cited 2024 May 6]. Available from: https://worldathletics.org

9. ABRAM - Associação Brasileira de Atletismo Master. História do Atletismo no mundo [cited 2025 Mar 24]. Available from: https://abrambrasil.com.br/atletismo-master

10. Tayrose GA, Beutel BG, Cardone DA, Sherman OH. The masters athlete. Sports Health. 2015;7(3):270-6. https://doi.org/10.1177/1941738114548999

11. Trappe S. Master athletes. Int J Sport Nutr Exerc Metab. 2001;11 Suppl:S196-207. https://doi.org/10.1123/ijsnem.11.s1.s196

12. Dionigi AR. Esporte master: saúde, bem-estar e qualidade de vida na maturidade. São Paulo: Manole; 2008.

13. Young BW, Bennett A, Séguin B. Master sports perspectives. In: Routledge handbook of sports event management: A stakeholder approach. London: Routledge; 2015.

14. Lazzoli JK, Oliveira MAB, Leitão MB, Nóbrega ACL, Nahas RM, Rezende L, et al. Posicionamento oficial da Sociedade Brasileira de Medicina do Esporte sobre: esporte competitivo em indivíduos acima de 35 anos. Rev Bras Med Esporte. 2001;7(3):83-92. https://doi.org/10.1590/S1517-86922001000 300004

15. Gervasi SF, Palumbo L, Cammarano M, Orvieto S, Di Rocco A, Vestri A, et al. Coronary atherosclerosis in apparently healthy master athletes discovered during pre-PARTECIPATION screening. Role of coronary CT angiography (CCTA). Int J Cardiol. 2019;282:99-107. https://doi.org/10.1016/j.ijcard.2018.11.099

16. Tso J, Kim JH. Master endurance athletes and cardiovascular controversies. Curr Sports Med Rep. 2020;19(3):113-8. https://doi.org/10.1249/jsr.0000000000000695

17. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 2020;54(24):1451-62. https://doi.org/10.1136/bjsports-2020-102955

18. Corrado D, Zorzi A. Sudden death in athletes. Int J Cardiol. 2017;237:67-70. https://doi.org/10.1016/j.ijcard.2017.03.034

19. Morrison BN, McKinney J, Isserow S, Lithwick D, Taunton J, Nazzari H, et al. Assessment of cardiovascular risk and preparticipation screening protocols in masters athletes: the Masters Athlete Screening Study (MASS): a cross-sectional study. BMJ Open Sport Exerc Med. 2018;4(1):e000370. https://doi.org/10.1136/bmjsem-2018-000370

20. Abbatemarco JR, Bennett C, Bell AJ, Dunne L, Matsumura ME. Application of pre-participation cardiovascular screening guidelines to novice older runners and endurance athletes. SAGE Open Med. 2016;4:2050312115616136. https://doi.org/10.1177/2050312115616136

21. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. https://doi.org/10.1136/bmj.n71

22. Hernandes E, Zamboni A, Fabbri S, Thommazo AD. Using GQM and TAM to evaluate StArt - A tool that supports Systematic Review. CLEI Electr J. 2012;15(1):3-3. https://tinyurl.com/mr2sr8te

23. Moola S, Munn Z, Sears K, Sfetcu R, Currie M, Lisy K, et al. Conducting systematic reviews of association (etiology): The Joanna Briggs Institute's approach. Int J Evid Based Health. 2015; 13(3):163-9. https://doi.org/10.1097/xeb.0000000000000064

24. Martin J. Joanna Briggs Institute 2017 Critical Appraisal Checklist for Cohort Studies. 2017 [cited 2025 Apr 17]. Available from: https://tinyurl.com/2erj92n9

25. Tischer U, Hartmann-Tews I, Combrink C. Sport participation of the elderly—the role of gender, age, and social class. Eur Rev Aging Phys Act. 2011;8:83-91. https://doi.org/10.1007/s11556-011-0087-8

26. Merghani A, Malhotra A, Sharma S. The U-shaped relationship between exercise and cardiac morbidity. Trends Cardiovasc Med. 2016;26(3):232-40. https://doi.org/10.1016/j.tcm.2015.06.005

27. Ghorayeb N, Stein R, Daher DJ, Silveira AD, Oliveira Filho JA, Ritt LEF, Santos DFP, et al. The Brazilian Society of Cardiology and Brazilian Society of Exercise and Sports Medicine Updated Guidelines for Sports and Exercise Cardiology - 2019. Arq Bras Cardiol. 2019;112(3):326-68. https://doi.org/10.5935/abc.20190048

28. Myrstad M, Løchen ML, Graff-Iversen S, Gulsvik AK, Thelle DS, Stigum H, et al. Increased risk of atrial fibrillation among elderly Norwegian men with a history of long-term endurance sport practice. Scand J Med Sci Sports. 2014;24(4):e238-44. https://doi.org/10.1111/sms.12150

29. German CA, Fanning J, Singleton MJ, Shapiro MD, Brubaker PH, Bertoni AG, et al. Physical activity, coronary artery calcium, and cardiovascular outcomes in the Multi-Ethnic Study of Atherosclerosis (MESA). Med Sci Sports Exerc. 2022;54(5):800-6. https://doi.org/10.1249/mss.0000000000002856

30. Merghani A, Maestrini V, Rosmini S, Cox AT, Dhutia H, Bastiaenan R, et al. Prevalence of subclinical coronary artery disease in masters endurance athletes with a low atherosclerotic risk profile. Circulation. 2017;136(2):126-37. https://doi.org/10.1161/circulationaha.116.026964

31. Shapero K, Deluca J, Contursi M, Wasfy M, Weiner RB, Lewis GD, et al. Cardiovascular Risk and disease among masters endurance athletes: insights from the Boston MASTER (Masters Athletes Survey To Evaluate Risk) Initiative. Sports Med Open. 2016;2:29. https://doi.org/10.1186/s40798-016-0053-0

32. Panhuyzen-Goedkoop NM, Wellens HJ, Verbeek AL, Jørstad HT, Smeets JR, Peters RJ. ECG criteria for the detection of high-risk cardiovascular conditions in master athletes. Eur J Prev Cardiol. 2020;27(14):1529-38. https://doi.org/10.1177/2047487319901060

33. Fyyaz S, Papadakis M. Arrhythmogenesis of sports: myth or reality? Arrhythm Electrophysiol Rev. 2022;11:e05. https://doi.org/10.15420/aer.2021.68

34. Cavigli L, Zorzi A, Spadotto V, Mandoli GE, Melani A, Fusi C, et al. The acute effects of an ultramarathon on atrial function and supraventricular arrhythmias in master athletes. J Clin Med. 2022;11(3):528. https://doi.org/10.3390/jcm11030528

35. Gao JW, Hao QY, Lu LY, Han JJ, Huang FF, Vuitton DA, et al. Associations of long-term physical activity trajectories with coronary artery calcium progression and cardiovascular disease events: results from the CARDIA study. Br J Sports Med. 2022;56(15):854-61. https://doi.org/10.1136/bjsports-2021-105092

36. Bosscher R, Dausin C, Claus P, Bogaert J, Dymarkowski S, Goetschalckx K, et al. Lifelong endurance exercise and its relation with coronary atherosclerosis. Eur Heart J. 2023;44(26):2388-99. https://doi.org/10.1093/eurheartj/ehad152

37. Aengevaeren VL, Mosterd A, Braber TL, Prakken NHJ, Doevendans PA, Grobbee DE, et al. Relationship between lifelong exercise volume and coronary atherosclerosis in athletes. Circulation. 2017;136(2):138-48. https://doi.org/10.1161/circulationaha.117.027834

38. Abdullah SM, Barkley KW, Bhella PS, Hastings JL, Matulevicius S, Fujimoto N, et al. Lifelong physical activity regardless of dose is not associated with myocardial fibrosis. Circ Cardiovasc Imaging. 2016;9(11):e005511. https://doi.org/10.1161/circimaging.116.005511

39. Fruytier LA, van de Sande DAJP, Kemps HMC. Exercise-related major adverse cardiovascular events in asymptomatic recreational master athletes: a case series. Eur Heart J Case Rep. 2022;6(8):ytac309. https://doi.org/10.1093/ehjcr/ytac309