Does cardiovascular preparticipation screening cause psychological distress in athletes? A systematic review

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ABSTRACT

Objective To evaluate the psychological implications of cardiovascular preparticipation screening (PPS) in athletes.

Design Systematic review.

Data sources MEDLINE, EMBASE, PubMed, CINAHL, SPORTDiscus, APA PsycInfo, Cochrane Library and grey literature sources.

Study eligibility criteria Observational and experimental studies assessing a population of athletes who participated in a cardiovascular PPS protocol, where psychological outcomes before, during and/or after PPS were reported.

Methods Results of included studies were synthesised by consolidating similar study-reported measures for key psychological outcomes before, during and/or after screening. Summary measures (medians, ranges) were computed across studies for each psychological outcome.

Results A total of eight studies were included in this review (median sample size: 479). Study cohorts consisted of high school, collegiate, professional and recreational athletes (medians: 59% male, 20.5 years). Most athletes reported positive reactions to screening and would recommend it to others (range 88%–100%, five studies). Increased psychological distress was mainly reported among athletes detected with pathological cardiac conditions and true-positive screening results. In comparison, athletes with false-positive screening results still reported an increased feeling of safety while participating in sport and were satisfied with PPS. A universal conclusion across all studies was that most athletes did not experience psychological distress before, during or after PPS, regardless of the screening modality used or accuracy of results.

Conclusion Psychological distress associated with PPS in athletes is rare and limited to athletes with true-positive findings. To mitigate downstream consequences in athletes who experience psychological distress, appropriate interventions and resources should be accessible prior to the screening procedure.

PROSPERO registration number CRD42021272887.

WHAT IS ALREADY KNOWN?

⇒ Although many international organisations endorse cardiovascular preparticipation screening (PPS) for athletes, the use of screening components, such as a history questionnaire, physical examination and ECG, is not standardised globally.
⇒ One point of contention with the uptake of cardiovascular PPS is the potential psychological impact it has on athletes, particularly when sensitive tools, such as an ECG, are included.
⇒ The psychological impact of cardiovascular PPS in athletes has not been comprehensively summarised.

WHAT ARE THE NEW FINDINGS?

⇒ The majority of athletes reported no/minimal measurable psychological distress before, during and after cardiovascular PPS.
⇒ Most athletes reported positive reactions to PPS, including feeling safer during sport after screening, expressing a positive impact of screening on their training, feeling satisfied with their PPS examination and recommending PPS to other athletes.
⇒ Increased psychological distress was mainly reported among athletes detected with pathological cardiac conditions and true-positive screening results, identifying this population as an important target for interventional approaches aimed to mitigate downstream psychological consequences.

INTRODUCTION

Sudden cardiac death (SCD) is the leading cause of mortality among athletes during sports and exercise.[1] The prevention of SCD in athletic settings is of tremendous importance given the profound societal impact of these events on families and communities, especially when occurring in a young and seemingly healthy athlete.[1–5] To minimise the occurrence of these tragic events, international organisations, including the Canadian Cardiovascular Society, Canadian Heart Rhythm Society, American Heart Association, American Medical Society for Sports Medicine and European Society of Cardiology endorse cardiovascular preparticipation screening (PPS).[3 6–8] However, the recommended screening components, such as a medical history questionnaire, physical examination, ECG testing and other diagnostic tests, vary across these international organisations.[1 3–5 9–11] Recommendations are most inconsistent regarding the use of a 12-lead ECG as a standard test for screening protocols, with debate surrounding the cost-effectiveness, diagnostic accuracy and psychological implications of potential false-positive results.[3 4 9 12]

One major point of contention with the uptake of cardiovascular PPS is the potential psychological impact it has on athletes, particularly when sensitive tools, such as an ECG,[11–13] are used. Although the stated objective of all PPS (regardless of protocol) is to detect athletes at risk of SCD, diagnosis with

a cardiac disease following PPS may result in exercise modification or restriction and may dramatically alter an athlete's identity and life.[11 14 15] Previous evidence has shown that coping with a newly diagnosed cardiac condition, even if unlikely to lead to SCD or other adverse events, can increase the risk of psychological morbidity, which may be more exaggerated than a diagnosis in the non-athletic population.[11] However, there is uncertainty regarding the psychological impact of cardiovascular PPS among the general athletic population, which has contributed to heterogeneity in screening practices across institutions/organisations.[16] The presumed unnecessary anxiety and psychological distress caused by false-positive results, particularly with ECG screening, has sparked debate within the sports medicine and cardiology communities.[9 12] To better understand the athletic response to cardiovascular PPS, the objective of this systematic review was to summarise the psychological implications of cardiovascular screening in athletes.

METHODS

Protocol and registration

The methodology for this systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, ensuring a uniform, systematic and transparent approach to study inclusion, data synthesis and review structure.[17] The PRISMA checklist for this systematic review is shown in the online supplemental material 1. The review protocol was registered in the PROSPERO international systematic review database prior to commencing the search process (registration number: CRD42021272887).

Eligibility criteria

Observational and experimental research studies published in English were included in this review. The study question was defined using the PICOS (Population, Intervention, Comparison, Outcome, Study Design) framework. We identified studies of athletes (P) who participated in a cardiovascular PPS protocol (I). An athlete was generally defined as any individual who engages in physical activity with the primary goal of improving performance to enhance their athletic excellence and/or achievement.[18] Participation in a cardiovascular PPS protocol was defined as undergoing cardiovascular screening prior to engagement in competitive sport; the screening protocol must have included at least one of, but not limited to, a standardised cardiovascular questionnaire/medical history, physical examination and/or 12-lead ECG (I). A comparator group was not applicable to the study question and thus we did not mandate studies to have one for inclusion in our review (C). Only studies reporting psychological outcomes before, during and/or after cardiovascular screening were included (O). Psychological outcomes included depression, anxiety, stress, strain, worry, fear, intrusive thoughts and/or attitudes towards PPS (O). To allow for acceptable comparisons between studies, only observational studies with a patient population of $n>10$ were included. Studies that reported outcomes derived from a cohort with cardiac disease but without specification of the cardiovascular PPS protocol were excluded (S). Abstracts or conference papers were also excluded (S).

Information sources and search strategies

We conducted literature searches in MEDLINE (1946–present), EMBASE (1947–present), PubMed (1966–present), CINAHL (1937–present), SPORTDiscus (1892–present), APA PsycInfo (1806–present) and Cochrane Library (1991–present) electronic databases on 22 July 2021. Focused grey literature searches of Google Scholar (first 300 results, sorted by relevance), as previously suggested,[19] and CADTH Grey Matters were performed throughout July 2021. Our electronic search strategies, specific for each database, are shown in the online supplemental material 1.

Study selection process

Study selection was performed using the electronic systematic review management platform Covidence, which has demonstrated high accuracy in the identification of duplicate records.[20] All duplicate records were identified and removed automatically. Title and abstract screening were performed by two independent reviewers (BH and MW). Any conflicts regarding the inclusion or exclusion of articles were discussed until a consensus was reached. If a consensus could not be reached, a third reviewer provided an independent decision to resolve any conflicts (NG). Full-text review was conducted by the same two independent reviewers, with any disagreements resolved by discussion until a consensus was reached. A Cohen's kappa (κ) statistic and 95% CI for inter-rater reliability were calculated at the abstract screening stage. A 'backward snowballing' process was performed by reviewing the reference lists of included full-text articles for additional articles that may be relevant.[21] Any additional articles identified at this stage were judged for inclusion using the same process outlined above.

Data collection and data items

Data extraction of included articles was performed in duplicate by two independent reviewers (BH and MW) using a standardised data collection form. All results were reviewed for relevance and confirmed by a medical professional involved in cardiovascular care of athletes and exercisers (AMJ). The variables extracted from each study included first author's name, year of publication, geographical location, study design, cardiovascular screening methods used, sample size, patient characteristics (age and sex), psychometric instrument(s) used, and psychological outcomes before, during, and/or after screening. Full copies of each psychometric scale used to collect study outcomes are shown in online supplemental tables S1–S3.

Risk of bias in individual studies

For the purpose of evaluating the risk of bias in included studies, the standardised instruments from the Joanna Briggs Institute (JBI) were used.[22] These instruments included the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies (8 items), the JBI Critical Appraisal Checklist for Qualitative Research (10 items) and the JBI Critical Appraisal Checklist for Quasi-Experimental (Non-Randomized Experimental) Studies (9 items), which were chosen accordingly to the study design. These checklists were designed to assess the methodological quality of a study and to determine the extent to which a study had addressed the possibility of bias in its design, conduct and analysis.[23] The JBI instruments have been previously recommended as valid critical appraisal tools for systematic reviews.[24] Each item of the checklist corresponds to a critical appraisal question with four possible responses: yes (the criteria are clearly identifiable through the report description or have been confirmed by the primary author); unclear (the criteria are not clearly identified in the report, and it was not possible to acquire clarification from the author); no (the criteria failed to be applied appropriately); not applicable (the criteria were not relevant to the study). All included studies were evaluated using the applicable checklists by two independent reviewers (BH and MW),

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and the score (or range if scores differed between reviewers) was presented. A rating of 'yes' on a checklist item was awarded as 1 point to the study, whereas ratings of 'unclear', 'no' or 'not applicable' were awarded 0 points. The JBI Checklists used in this systematic review are shown in online supplemental tables S4–S6.

Synthesis approach

Given the heterogeneity in reported outcomes, as well as the methodological diversity across the included studies, we were unable to perform a formal meta-analysis.[25] In lieu of a meta-analysis, we synthesised the results of included studies by consolidating similar study-reported measures for key psychological outcomes at three time points (ie, before screening, during screening, after screening). Summary measures (medians, ranges) were computed across studies for each psychological outcome. Among studies which did not provide a mean measurement of the cohort, and instead only provided measurements for subgroups, an overall sample mean was produced by calculating the weighted mean among all subgroups in the study cohort. To account for the varied terminology used to ascertain psychological distress across included studies, we defined this outcome as a composite measure of anxious and depressive symptoms including strain, stress, worry, intrusion and fear, in accordance with suggested definitions of psychological distress symptomatology.[26 27] As psychological outcomes were collected using various instruments, we provided separate summary measures for studies that used Likert scales (ie, all Likert scales ranged from 1 to 5; 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree) versus binary variables. All details on how the findings of each study were modified to produce the summary measures in this review are summarised in online supplemental appendix A1.

As a sensitivity analysis, we assessed the psychological implications of cardiovascular screening among studies which stratified findings by screening results—athletes who screened true positive, false positive and normal. A true positive was defined as a new diagnosis of a pathological cardiac condition associated with SCD in athletes. A false positive was defined as any initial abnormal screening test which was later deemed as normal following subsequent testing. All analyses were performed using Excel V.16.58 software (Microsoft, Redmond, Washington, USA).

RESULTS

Study selection

Following electronic literature searches, we identified 2672 records from databases, 266 records from registers and 22 records from grey literature sources. After the removal of

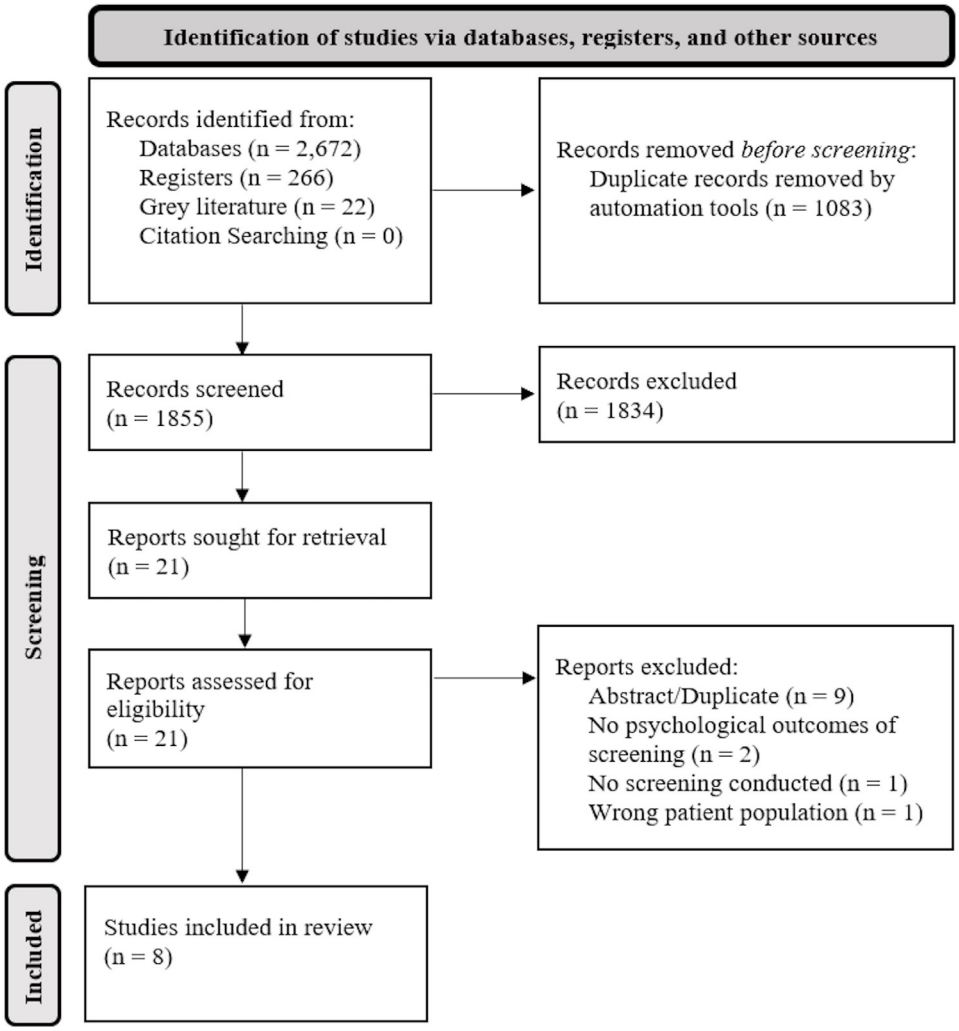

Figure 1 PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) study selection flow chart.

Table 1 Characteristics of included studies

First author (year of publication)	Country	Study design	Screening components	Sample	Male (%)	Age (years)	Risk of bias score
Asif (2014)[9]	USA	Non-randomised controlled trial	History, physical, ECG	High school athletes (n=952)	50	15.5	8*
Asif (2015)[5]	USA	Cross-sectional	History, physical, ECG	High school athletes (n=1516)	59	15.6	7–8
Asif (2015)[11]	USA	Qualitative	Not specified	High school and collegiate athletes diagnosed with cardiac condition (n=25)	52	17.7*	8†
Asif (2017)[29]	USA	Cross-sectional	History, physical, ECG	Collegiate athletes (n=1192)	55	19.0*	8
Morrison (2020)[30]	Canada	Cross-sectional	History, physical, ECG	Masters athletes (≥35 years) diagnosed with CVD (n=67)	90	60.1	7
Schurink (2017)[31]	Netherlands	Cross-sectional	History, physical, ECG, cardiac CT	Masters athletes (≥45 years) (n=275)	100	54.5	7–8
Solberg (2012)[39]	Norway	Cross-sectional	History, physical, ECG, echocardiography	Professional athletes (n=441)	100	26.0	6
Tischer (2016)[40]	Denmark	Cross-sectional	History, physical, ECG, echocardiography	Professional athletes (n=516)	59	21.6	6–8

Age (years) is reported as mean or *median.
*Evaluated using Joanna Briggs Institute Checklist for Quasi-Experimental Studies (Non-Randomized Experimental Studies).
†Evaluated using Joanna Briggs Institute Checklist for Qualitative Research.
CVD, cardiovascular disease.

duplicates, 1855 records were assessed for inclusion through title and abstract screening. A total of 21 studies were selected for full-text review, with a Cohen's κ of 0.88 (95% CI: 0.78 to 0.98), indicating excellent agreement.[28] Following the full-text review to assess for eligibility, 13 studies were excluded, leaving 8 eligible studies in our systematic review for qualitative synthesis (figure 1).

Study characteristics and risk of bias

The characteristics of included studies are shown in table 1. Among the eight included articles, six were cross-sectional studies, one was a non-randomised controlled trial and one was a qualitative study. All but one study included the following components within their PPS protocol: review of medical history, a physical examination and a 12-lead ECG. Some screening protocols incorporated imaging studies, such as echocardiography and cardiac CT. The median sample size was 479 (range: 25–1516). The study samples were primarily comprised of young athletes (median age: 20.5 years) who were mostly male (median: 59%, range: 50%–100%). Samples represented a broad range of athletic competition, including high school, collegiate, masters (≥35 years of age) and professional athletes.

All studies were of good overall quality and had a low risk of bias. The risk of bias for included cross-sectional studies, as assessed through the JBI Checklist for Analytical Cross-Sectional Studies ranged from 6/8 to 8/8 points. The risk of bias for the included non-randomised controlled trial, assessed using the JBI Checklist for Quasi-Experimental Studies, was rated at 8/9 points. The risk of bias for the included qualitative study was rated at 8/10 points using the JBI Checklist for Qualitative Studies. The JBI Critical Appraisal Tool scores for each included study, as evaluated by both reviewers, are reported in online supplemental tables S7–S9.

Results of individual studies and summary measures

For each included study, a summary of the psychometric instruments used, and main psychological outcomes reported before, during, and after cardiovascular PPS is provided in online supplemental table S10. All but one study measured psychological outcomes through self-administered questionnaires, which were administered to athletes prior to and at a specific time point following screening.[5 8 27–31] The other study assessed psychological outcomes through semistructured interviews conducted several months after screening.[11] Psychological distress before, during, and after screening was reported by seven, four, and seven included studies, respectively. Other psychometric variables assessed after screening included an increased feeling of safety during sport (six studies), a positive impact of screening on athletic training (four studies), overall satisfaction with screening (six studies) and recommendation of screening to other athletes (eight studies) (online supplemental table S11).

The summary measures for psychological outcomes before, during and after screening are shown in table 2. The majority of athletes reported no/minimal measurable psychological distress before (median Likert score/proportion: 1.87/6.3%), during (median Likert score/proportion: 2.69/5%) and after (median Likert score/proportion: 2.05/25%) cardiovascular PPS. Athletes typically felt safer during sport after screening (median Likert score/proportion: 3.46/59%) and expressed that cardiovascular screening had a positive impact on their training (median Likert score/proportion: 3.74/60%). Additionally, the vast majority of athletes were satisfied with their cardiovascular preparticipation examination (median Likert score/proportion: 4.30/93%) and would recommend screening to other athletes (median Likert score/proportion: 4.28/92%).

Post-hoc analyses

The results of the sensitivity analysis are presented in the online supplemental table S12. Athletes who screened normal or false-positive typically reported no/minimal measurable psychological distress before (normal median Likert score/proportion: 1.87/7.9%; false-positive median Likert score: 1.94), during (normal median Likert score/proportion: 2.71/5.7%; false-positive median Likert score: 2.78) and after screening (normal median Likert score/proportion: 2.18/3.1%; false-positive median Likert score: 2.06), with no significant differences in

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Table 2 Summary measures among studies reporting psychological outcomes of screening

Psychological outcome	Median Likert score (1–5)*	Range of Likert scores (1–5)*	Number of eligible studies	N	Median (%)	Range (%)	Number of eligible studies	N
Before screening								
Psychological distress†	1.87	1.87	1	516	6.3	4.2–16	6	4443
During screening								
Psychological distress†	2.69	2.23–2.73	3	3660	5	5	1	275
After screening								
Psychological distress†	2.05	1.81–2.19	4	4176	25	15–29	3	783
Feel safer during sport	3.46	3.20–3.55	3	3660	59	45–64	3	783
Positive impact on training	3.74	3.43–3.85	3	3660	60	60	1	275
Satisfied with screening	4.30	4.19–4.41	3	3660	93	88–94	3	783
Recommend screening to other athletes	4.28	3.59–4.32	3	3660	92	75–100	5	2324

*Likert scale values reported under median Likert score and range of Likert scores reflect sample mean values reported among each eligible study (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree).
†Psychological distress is a composite measure describing all outcomes pertaining to athletes' self-reported distressing emotions (ie, depression, anxiety, worry, stress, strain, intrusion, fear) regarding cardiovascular preparticipation screening.

distress levels between these groups. Athletes who screened true positive and were subsequently diagnosed with a cardiac condition reported measurable distress during (median Likert score/proportion: 3.29/2.1%) and after screening (median Likert score/proportion: 3.36/27%). However, nearly all athletes were satisfied with screening and would recommend it to others, regardless of their screening results.

DISCUSSION

Summary of evidence

This is the first systematic review to evaluate the psychological implications of cardiovascular PPS in athletes. Our review found that athletes report no/minimal measurable levels of psychological distress before, during and after cardiovascular screening, unless a true cardiac diagnosis is identified. Among studies which evaluated the psychological impact of screening stratified by screening results, athletes who experienced a false-positive screen did not experience more psychological morbidity compared with those who screened normal. Moreover, a universal conclusion across all studies was that athletes were satisfied with the screening process, felt safer during competition after screening and would recommend PPS to others regardless of their screening results. Collectively, our findings suggest that cardiovascular PPS is not associated with undue or significant psychological distress in athletes.

A common argument against the uptake of more rigorous cardiovascular PPS is the psychological implications caused by screening, particularly when an ECG is used, mainly due to the possibility of false-positive findings.[9 12] However, with advancements in athletic ECG interpretation through the recently published International Criteria,[32] the rate of false-positive findings has dramatically declined (1.3%–6.8%) in comparison with prior recommendations.[33–36] Four studies included in this review reported psychological outcomes stratified by the screening results, among which a relatively low proportion of athletes screened false-positive by ECG (three studies; range: 1.7%–3.1%).[5 8 27] Importantly, the rate of false-positive findings was much higher if identified through the use of a medical questionnaire (two studies; 12.9%, 15.8%) or physical examination (4.2%, 6.2%).[5 9] Athletes who received false-positive screening results reported no/minimal measurable anxiety both during and after screening, with no significant differences in distress levels compared with athletes who screened normal.[5 9 29] These findings suggest that the perceived negative psychological impact of cardiovascular PPS is negligible and thus may have less relevance to the debate as to whether PPS (or components) should be instituted in a given context.

As expected, athletes who screened true positive and received a cardiac diagnosis did report measurable psychological distress following screening. Given that the stated aim of PPS is to detect athletes with conditions associated with SCD regardless of the protocol implemented, this finding is relevant to all forms of PPS. As this subgroup of athletes is most at risk of psychological morbidity following PPS,[5 9 11 29] psychological care following screening and routine follow-up should be a top priority for healthcare professionals responsible for the cardiovascular care of athletes. Previous work has defined a four-stage model of psychological impact in athletes after receiving a cardiovascular diagnosis, consisting of (1) immediate reaction and challenge to athlete identity, (2) grief and coping, (3) adaptation and (4) acceptance.[11] This study noted that athletes diagnosed with a cardiac condition during cardiovascular PPS reported dissatisfaction with their care, mainly due to unclear physical activity recommendations and limited emotional support from members of their care team. With no currently published guidelines informing the psychological care of athletes following PPS, these findings highlight the need for athlete-specific tools to: (1) guide physicians in identifying athletes at risk of adverse psychological outcomes, and (2) tailor psychological care and emotional support. Such tools could be modelled from recommendations for psychological care following diagnosis of cardiovascular diseases[37] or other chronic diseases, such as cancer.[38]

Some studies included in this systematic review investigated the psychological implications of the cardiovascular screening of athletes according to sociodemographic characteristics including ethnicity, gender and age. One study noted differences in prescreen attitudes between African-American and Caucasian athletes, with Caucasian athletes expressing a stronger desire to know about an underlying cardiac abnormality before competing.[5] However, no significant differences in reported psychological outcomes during and after screening between these groups were found. Consistent findings were noted in a similar study led by the same group.[29] Sex differences were also noted, with men expressing less concerns surrounding the potential for abnormal screening results and less distress during screening than women. On the other hand, women were more likely to prefer

to know of a cardiac abnormality before competing and agree with temporary sports restriction.[5] However, there were no significant differences between these groups with respect to post-screening psychological distress and perceptions of screening.[5] Experiences with screening also did not appear to differ with age, sport or level of competition.[5 29] Studies which evaluated cohorts of high school,[5 9 11] collegiate,[11 29] professional[39 40] and masters[30 31] athletes demonstrated similar results, suggesting that the psychological response to cardiovascular PPS is similar across age groups and levels of competition. Healthcare professionals involved in the cardiovascular care of athletes should be cognisant of sociodemographic factors which may play an influential role in their response to PPS. Future studies should assess for differences in psychological impact across sociodemographic subgroups (eg, sex, gender, race/ethnicity), which may help to inform tailored recommendations or identify groups at risk of psychological morbidity.

Clinical implications

It is well known that diagnosis with a cardiac disorder can result in psychological morbidity and have a profound impact on perceived quality of life.[4] For athletic populations, psychological sequelae following a cardiac diagnosis may be profound as follow-up evaluations, exercise modification/restriction or sport disqualification has the potential to dramatically impact mental health and well-being. As demonstrated in our review, although no (or low) levels of psychological distress were reported among athletes undergoing cardiovascular PPS, these findings are not consistent across test results, especially in athletes who screen true positive. Care providers should be aware that physical activity and competition are integral to an athlete's self-identity and ability to cope with stress, and if removed, can lead to substantial psychological burden.[4 11 41–44] Therefore, it is crucial that psychological resources are accessible for athletes both before, during and after the screening process, particularly for those who receive a true-positive test result. Care providers may consider using existing athlete mental healthcare recommendations when providing counsel to athletes, such as those designed by the IOC,[45 46] American Medical Society for Sports Medicine,[47] or Canadian Centre for Mental Health and Sport.[48 49] For example, mental health support, such as psychotherapy or alternative care strategies, should be made available to athletes by their institution, sports organisation or community.[15 50] Providing access to a multidisciplinary cardiac genetic team to discuss treatment and management decisions following diagnosis should also be a top priority.[4] Furthermore, all athletes should be educated on the screening process and follow-up workflow, regardless of their screening result. This could involve providing athletes with informational pamphlets or online resources that outline the importance of screening, the cardiovascular conditions being screened for and the screening process.

Among the eight studies included in this review, all of which used an ECG to screen all or some of their athletic samples; a universal conclusion was that cardiovascular PPS caused minimal measurable psychological distress. Cardiovascular PPS, regardless of the screening modalities used, was also highly recommended by athletes, even across true-positive, false-positive and normal test result subgroups. These findings suggest that the potential psychological distress caused by ECG screening should not be cited as the sole reason to exclude ECG from PPS programmes.

Policy implications

At present, there is currently no standardised approach to the psychological management and monitoring of athletes throughout the cardiovascular PPS process.[3 4 15] With no formal recommendations to guide the psychological care of athletes undergoing PPS, there is a need for improved communication and support from athletic cardiovascular care providers. Instead of forgoing screening practices (ie, ECG) to prevent potential psychological responses in athletic populations, the design and use of psychological well-being tools that can be provided to athletes during and following screening should be considered. Future research may wish to evaluate the value of integrating a short psychological questionnaire as a component of routine cardiovascular PPS, allowing for the identification of athletes who may benefit from mental health resources and clinical follow-up. Given the strong relationship between exercise, cardiovascular health and psychological health,[51–55] the generation of psychological screening assessments that can be used in parallel with cardiovascular PPS may help to advance the delivery of compassionate care to athletes.

Some studies included in this review reported that athletes expressed dissatisfaction with their care following screening (eg, lack of clarity)[11] or desired additional support after screening.[30] However, given the quantitative nature of almost all studies included in this review, there is little indication of how the psychological care process can be improved to better suit the needs of athletes undergoing PPS. To fulfil this knowledge gap, further mixed-methods research is needed to understand athletic perspectives on PPS, as well as identify the key barriers and facilitators to the provision of psychological care throughout the PPS process.[11] This may contribute to the development of policy recommendations for the delivery of mental health counselling throughout the PPS process, in addition to the design of screening tools that can help to identify athletes at risk of psychological morbidity.

Limitations

There are important limitations of this review at the study and outcome level. First, there was significant diversity in study designs, screening modalities and psychometric instruments used across studies in this review, which prevented the conduct of a formal meta-analysis. Second, there was heterogeneity among study samples included in our review, ranging dramatically in sample size (ie, 25–1516 participants) and patient composition (ie, high school to masters athletes, representing a broad level of competition across various sports). There was also an inherent potential for recall bias among the included studies, given differences in timing of data collection for psychological outcomes and parameters. Although prescreen assessments were relatively uniform in timing, the point at which post-screen questionnaires were provided to athletes varied significantly, with studies providing post-screen assessments immediately after,[5 9 29] 3 days after,[40] 2–3 months after,[39] or greater than 6 months after completion of screening and follow-up examinations.[30 31] As the psychological impact of screening may diminish as individuals have more time to understand and accept a result,[56 57] this may have biased our overall summary measures for psychological outcomes. Lastly, social desirability bias, which involves a tendency of participants to give socially desirable responses instead of responses that are reflective of their true feeling, may have influenced the findings of studies included in this review, given the behavioural nature of data elements that were collected.[58]

Additionally, there are several notable limitations at the review level. First, to ensure consistency, studies reporting the psychological outcomes of a cardiac diagnosis without specification of the cardiovascular screening process were not eligible for this review, which may have excluded some relevant results. However, these studies did note similar conclusions, with notable psychological distress associated with true-positive screening results but still a high rate of satisfaction and recommendation of PPS regardless.[43 44 59] Moreover, this review was unable to reliably assess potential sociodemographic differences in the psychological implications of screening due to a lack of reporting across the included studies. This should be a focus of future research. Moreover, only studies written in English were included, and studies with ≤10 participants were excluded to weaken potential publication biases. Finally, the results of this review were largely based on observational studies using subjective psychometric questionnaires, which may be subject to confounding or other biases.

CONCLUSIONS

This systematic review demonstrates that cardiovascular PPS was associated with no/minimal psychological distress in athletes. However, a small proportion of athletes, almost exclusively those with true-positive screening results, do experience psychological distress following screening. Regardless of screening results, athletes reported an enhanced feeling of safety while participating in sport and would recommend PPS to other athletes. Our findings support that psychological distress due to screening should not be cited as a reason to forgo cardiovascular PPS. For athletes with negative reactions to PPS, it is imperative that appropriate resources be made accessible and routine follow-up be performed to mitigate potential downstream consequences.

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Supplementary Material

Does cardiovascular preparticipation screening cause psychological distress in athletes? A systematic review

Hill B, Grubic N, Williamson M, Phelan D, Baggish A, Dorian P, Drezner JA & Johri AM (2022)

Hill B, *et al. Br J Sports Med* 2022;0:1–8. doi: 10.1136/bjsports-2022-105918

Database Search Strategies

Database searches using the specified search strategies are shown below for each database or database group.

MEDLINE, EMBASE, APA PsycInfo: exported on July 22, 2021 (1734 total records)

1 cardiovascular.mp. (1781225)
2 cardiac.mp. (1906041)
3 heart.mp. (4136190)
4 cardiology.mp. (225011)
5 screening.mp. (1909140)
6 preparticipation.mp. (2157)
7 pre-participation.mp. (1299)
8 sport*.mp. (322694)
9 exercise*.mp. (1086973)
10 athlet*.mp. (231076)
11 psych*.mp. (5829114)
12 mental.mp. (2119052)
13 depression.mp. (1535271)
14 anxiety.mp. (927007)
15 1 or 2 or 3 or 4 (5696815)
16 5 or 6 or 7 (1910247)
17 8 or 9 or 10 (1407083)
18 11 or 12 or 13 or 14 (7650138)
19 15 and 16 and 17 and 18 (1734)

PubMed, CINAHL, SPORTDiscus, Cochrane Library**:** exported on July 22, 2021 (1204 total records)

(cardiovascular* OR cardiac* OR heart* OR cardiology)
AND (screening OR pre-participation* OR preparticipation*)
AND (athlet* OR exercise* OR sport*)
AND (psych* OR mental* OR depression OR anxiety)

Targeted grey literature searches using Google Scholar and the Canadian Agency for Drugs and Technologies in Health (CADTH) Grey Matters tool were also conducted. The specified search strategies are shown below.

Google Scholar: exported on July 22, 2021 (14 total records)

(cardiovascular AND athlete AND screening AND psychology)

CADTH Grey Matters: exported on July 22, 2021 (8 total records)

Searched using a combination of the terms/phrases listed above.

Supplemental Table S1. Self-administered pre-screen and post-screen questionnaires used by Asif et al., (2014), Asif et al., (2015), and Asif et al., (2017) [1]**.**

Heart Screening Questionnaire: Pre-Screen

Your school is interested in protecting its athletes. This includes trying to detect heart conditions during your pre-participation exam. We want toknow how you feel about detecting heart problems. For this questionnaire, an EKG (electrocardiogram) is a test that involves sensors to detect your heart's activity level.

Directions: For the following questions, please check the box that **best** describes your opinion.	**Yes**	**No**	**Uncertain**
1. Someone in my family or a close friend has had a heart condition at an early age (Less than 50 years old).	□	□	□
2. I have had a pre-participation exam before.	□	□	□

Directions: For the following questions, please check the box that **best** describesyour opinion. **Over the last four weeks, how often have you been bothered by the following problems…**	**Not at All**	**Several Days**	**More than Half the Days**
3. Feeling nervous, anxious, on edge, or worrying a lot about different things?	□	□	□
If you checked "Not at All", go to question number 4.			
a. Feeling restless so that it is hard to sit still?	□	□	□
b. Getting tired very easily?	□	□	□
c. Muscle tension, aches, or soreness?	□	□	□
d. Trouble falling asleep or staying asleep?	□	□	□
e. Trouble concentrating on things, such as reading a book or watching TV?	□	□	□
f. Becoming easily annoyed or irritable?	□	□	□

Hill B, *et al. Br J Sports Med* 2022;0:1–8. doi: 10.1136/bjsports-2022-105918

Directions: For the following questions, please check the box that **best** describes your opinion.	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
4. I have worried that I have a heart condition.	□	□	□	□	□
5. I am interested in having my heart screened prior to playing competitive sports.	□	□	□	□	□
6. I am interested to undergo a heart screen that includes an EKG prior to playing competitive sports.	□	□	□	□	□
7. I am worried that this heart screen will reveal that I have a heart condition.	□	□	□	□	□
8. If I had a heart condition, I would rather know than play sports without knowing.	□	□	□	□	□
9. If I had a heart condition, I would rather know so that I can receive proper treatment.	□	□	□	□	□

Directions: for the next two questions, please consider the following statement. Afterwards, please check the box that **best** describes your opinion.	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
An EKG improves our ability to detect a heart problem. This could save your life. In some circumstances, results may require more testing (such as an ultrasound of the heart) before a final determination is made.					
10. I would want an EKG as part of my heart screen before I play competitive sports.	□	□	□	□	□
11. I would rather have the extra testing, even if I can't play sports temporarily, than play sports without knowing if my heart is healthy.	□	□	□	□	□

Heart Screening Questionnaire: Post-Screen TP Result

Additional testing was performed due to: □ **History** □ **Exam** □ **ECG**

Directions: For the following questions, please check the box that **best** describes your opinion.	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
1. The time period for receiving my results wasappropriate.	□	□	□	□	□
2. I was satisfied with this heart screen.	□	□	□	□	□

Hill B, *et al. Br J Sports Med* 2022;0:1–8. doi: 10.1136/bjsports-2022-105918

3. While undergoing the heart screen, I feltanxious.	□	□	□	□	□
4. I felt anxious or stressed while gettingadditional testing on my heart	□	□	□	□	□
5. Immediately after I received my final results, I feltanxious	□	□	□	□	□
6. I was scared that the heart screen would revealthat I had an abnormal heart.	□	□	□	□	□
7. Even though I needed additional testing, I amglad I had this heart screen.	□	□	□	□	□
8. Compared to other heart screens that I have had, I feel safer playing sports.	□	□	□	□	□
9. I feel that all athletes should receive a screenlike this before playing sports.	□	□	□	□	□
10. I would recommend this heart screen to otherathletes.	□	□	□	□	□
11. Even though I was found to have a heart condition, I am glad I had this heart screen.	□	□	□	□	□

12. I was told that I would be able to play my sport in the future.

□ Yes □ No

After all testing, my final diagnosis was _____

Heart Screening Questionnaire: Post-Screen FP Result

Additional testing was performed due to: □ **History** □ **Exam** □ **ECG**

Directions: For the following questions, please check the box that **best** describes your opinion.	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
1. I feel that all athletes should receive a screenlike this before playing sports.	□	□	□	□	□

2. I would recommend this heart screen to other athletes.	□	□	□	□	□
3. While undergoing the heart screen, I feltanxious.	□	□	□	□	□
4. I felt anxious or stressed while gettingadditional testing on my heart	□	□	□	□	□
5. After I received my results, I felt anxious orstressed.	□	□	□	□	□
6. I was scared that the heart screen would revealthat I had an abnormal heart.	□	□	□	□	□
7. I worried that someone would tell me I couldnot play sports.	□	□	□	□	□
8. Even though I needed additional testing, I amglad I had this heart screen.	□	□	□	□	□
9. Compared to other heart screens that I havehad, I feel safer playing sports.	□	□	□	□	□
10. The time period for receiving my results wasappropriate.	□	□	□	□	□
11. I was satisfied with this heart screen.	□	□	□	□	□
12. Compared to other athletes I think that I ammore likely to have a heart condition in the future.	□	□	□	□	□

13. The impact that this heart screen will have on my training/competition will be…

☐ Strongly Negative

☐ Slightly Negative

☐ Neutral

☐ Slightly Positive

☐ Strongly Positive

Heart Screening Questionnaire: Post-Screen Negative

Directions: For the following questions, please check the box that **best** describes your opinion.	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
1. The time period for receiving my results was appropriate.	□	□	□	□	□
2. I was satisfied with this heart screen.	□	□	□	□	□
3. While undergoing the heart screen, I felt anxious.	□	□	□	□	□
4. Immediately after I received my final results, I felt anxious	□	□	□	□	□
5. I was scared that the heart screen would reveal that I had an abnormal heart.	□	□	□	□	□

Directions: For the following questions, please check the box that **best** describes your opinion.	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
6. I worried that someone would tell me I could not play sports.	□	□	□	□	□
7. Compared to other heart screens that I have had, I feel safer playing sports.	□	□	□	□	□
8. I feel that all athletes should receive a screen like this before playing sports.	□	□	□	□	□
9. I would recommend this heart screen to other athletes.	□	□	□	□	□
10. Compared to other athletes I think that I am more likely to have a heart condition in the future.	□	□	□	□	□

11. The impact that this heart screen will have on my training/competition will be…

☐ Strongly Negative

☐ Slightly Negative

☐ Neutral

☐ Slightly Positive

☐ Strongly Positive

Adapted from: Asif IM, Johnson S, Schmieg J, et al. The psychological impact of cardiovascular screening: the athlete's perspective. Br J Sports Med 2014;48:1162–6. doi:10.1136/BJSPORTS-2014-093500

Supplemental Table S2. Impact of Event Scale-Revised (IES-R) including intrusion subscale used by Morrison et al., (2021), Schurink et al., (2017), and Solberg et al., (2012) [2].

INSTRUCTIONS:
Below is a list of difficulties people sometimes have after stressful life events. Please read each item, and then indicate how distressing each difficulty has been for you DURING THE PAST SEVEN DAYS with respect to _____, which occurred on _____. How much were you distressed or bothered by these difficulties?

Item Response Anchors are 0 = Not at all; 1 = A little bit; 2 = Moderately; 3 = Quite a bit; 4 = Extremely

The **Intrusion subscale** is the MEAN item response of **items 1, 2, 3, 6, 9, 14, 16, 20**. Thus, scores can range from 0 through 4.
The **Avoidance subscale** is the MEAN item response of **items 5, 7, 8, 11, 12, 13, 17, 22**. Thus, scores can range from 0 through 4.
The **Hyperarousal subscale** is the MEAN item response of **items 4, 10, 15, 18, 19, 21**. Thus, scores can range from 0 through 4.

IES-R Items:

1. Any reminder brought back feelings about it.
2. I had trouble staying asleep.
3. Other things kept making me think about it.
4. I felt irritable and angry.
5. I avoided letting myself get upset when I thought about it or was reminded of it.
6. I thought about it when I didn't mean to.
7. I felt as if it hadn't happened or wasn't real.
8. I stayed away from reminders of it.
9. Pictures about it popped into my mind.
10. I was jumpy and easily startled.
11. I tried not to think about it.
12. I was aware that I still had a lot of feelings about it, but I didn't deal with them.
13. My feelings about it were kind of numb.
14. I found myself acting or feeling like I was back at that time.
15. I had trouble falling asleep.
16. I had waves of strong feelings about it.
17. I tried to remove it from my memory.
18. I had trouble concentrating.
19. Reminders of it caused me to have physical reactions, such as sweating, trouble breathing, nausea, or a pounding heart.
20. I had dreams about it.
21. I felt watchful and on-guard.
22. I tried not to talk about it.

Score Interpretation (IES-R):
24-32: PTSD is a clinical concern. Those with scores this high who do not have full PTSD will have partial PTSD or at least some of the symptoms.
33-38: This represents the best cutoff for a probable diagnosis of PTSD.
39 and above: This is high enough to suppress your immune system's functioning (even 10 years after an impact event).

Adapted from: Daniel S. Weiss, Ph.D., Professor of Medical Psychology, Department of Psychiatry, University of California, San Francisco, CA 94143-0984. Mail Code: UCSF Box 0984-F. Mail Code: UCSF Box 0984-F. Tel.: (415) 476-7557. Email: daniel.weiss@ucsf.edu.

Supplemental Table S3. Scales and Items of the RESTQ-76 Sport, used by Tischer et al. (2017) [3].

Scale 1: General Stress
- (22) I felt down
- (24) I felt depressed
- (30) I was fed up with everything
- (45) Everything was too much for me

Scale 2: Emotional Stress
- (21) I was annoyed by others
- (26) Other people got on my nerves
- (38) I was upset
- (48) I was angry with someone

Scale 4: Conflicts/Pressure
- (12) I worried about unresolved problem
- (18) I couldn't switch my mind off
- (32) I felt I had to perform well in front of others
- (44) I felt under pressure

Scale 5: Fatigue
- (2) I did not get enough sleep
- (16) I was tired from work
- (25) I was dead tired after work
- (35) I was overtired

Scale 6: Lack of Energy
- (4) I was unable to concentrate well
- (11) I had difficulties in concentrating
- (31) I was lethargic
- (40) I put off making decisions

Scale 7: Somatic Complaints
- (7) I felt physicially bad
- (15) I had a headache
- (20) I felt uncomfortable
- (42) I felt physically exhausted

Scale 8: Success
- (3) I finished important tasks
- (17) I was successful in what I did
- (41) I made important decisions
- (49) I had some good ideas

Scale 9: Social Relaxation
- (6) I laughed
- (14) I had a good time with my friends
- (23) I visited some close friends
- (33) I had fun

Scale 10: Somatic Relaxation
- (9) I felt physically relaxed
- (13) I felt at ease
- (29) I felt physically fit
- (38) I felt as if I could get everything done

Scale 11: General Well-being
- (10) I was in good spirits
- (34) I was in a good mood
- (43) I felt happy
- (47) I felt content

Scale 12: Sleep Quality

(19) I fell asleep satisfied and relaxed
(27) I had a satisfying sleep
(36) I slept restlessly
(46) My sleep was interrupted easily

Scale 13: Disturbed Breaks

(51) I could not get rest during the breaks
(58) I had the impression there were too few breaks
(66) Too much was demanded of me during the breaks
(72) The breaks were not at the right times

Scale 14: Burnout/Emotional Exhaustion

(54) I felt burned out by my sport
(63) I felt emotionally drained from performance
(68) I felt that I wanted to quit my sport
(76) I felt frustrated by my sport

Scale 15: Fitness/Injury

(50) Parts of my body were aching
(57) My muscles felt stiff or tense during performance
(64) I had muscle pain after performance
(73) I felt vulnerable to injuries

Scale 16: Fitness/Being in Shape

(53) I recovered well physically
(61) I was in a good condition physically
(69) I felt very energetic
(75) My body felt strong

Scale 17: Burnout/Personal Accomplishment

(55) I accomplished many worthwhile things in my sport
(60) I dealt very effectively with my teammates' problems
(70) I easily understood how my teammate felt about things
(77) I dealt with emotional problems in my sport very calmly

Scale 18: Self-Efficacy

(52) I was convinced I could achieve my set goals during performance
(59) I was convinced that I could achieve my performance at any time
(65) I was convinced that I performed well
(71) I was convinced that I had trained well

Scale 19: Self-Regulation

(56) I prepared myself mentally for performance
(62) I pushed myself during performance
(67) I psyched myself up before performance
(74) I set definite goals for myself during performance

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* Each item is scored on a 7-point Likert scale, with 0 representing strong disagreement and 6 representing strong agreement. Athletes respond to each item on a self-rated 7-point Likert scale according to how well the item was deemed to be self-descriptive for the previous 3 days and nights (0=strongly disagree, 6=strongly agree) [3].
Adapted from: Kellmann, Michael, and K. Wolfgang Kallus. Recovery-Stress Questionnaire for Athletes: User Manual. Champaign, IL: Human Kinetics, 2001. C.9

Risk of Bias Assessment

Standardized instruments provided by the Joanna Briggs Institute (JBI) were used to assess the risk of bias in included studies. The following scales were used:

The Newcastle-Ottawa Scale was used to assess the risk of bias in included studies. The following scales were used:

- JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies (Supplemental Table S4)
- JBI Critical Appraisal Checklist for Qualitative Research (Supplemental Table S5).
- JBI Critical Appraisal Checklist for Quasi-Experimental (Non-Randomized Experimental) Studies (Supplemental Table S6).

  The reviewer-specific scores for each included study are shown in Supplemental Table S7 (cross-sectional studies), Supplemental Table S8 (qualitative study), and Supplemental Table S9 (Quasi-experimental study).

Supplemental Table S4: JBI Critical Appraisal Checklist for Analytical Cross-sectional studies.

	Yes	No	Unclear	Not applicable
1. Were the criteria for inclusion in the sample clearly defined?	□	□	□	□
2. Were the study subjects and the setting described in detail?	□	□	□	□
3. Was the exposure measured in a valid and reliable way?	□	□	□	□
4. Were objective, standard criteria used for measurement of the condition?	□	□	□	□
5. Were confounding factors identified?	□	□	□	□
6. Were strategies to deal with confounding factors stated?	□	□	□	□
7. Were the outcomes measured in a valid and reliable way?	□	□	□	□
8. Was appropriate statistical analysis used?	□	□	□	□

Overall appraisal: Include □ Exclude □ Seek further info □

Adapted from: Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, Currie M, Qureshi R, Mattis P, Lisy K, Mu P-F. Chapter 7: Systematic reviews of etiology and risk . In: Aromataris E, Munn Z (Editors). JBI Manual for Evidence Synthesis. JBI, 2020. Available from https://synthesismanual.jbi.global

Supplemental Table S5: JBI Critical Appraisal Checklist for Qualitative Research.

		Yes	No	Unclear	Not applicable
1.	Is there congruity between the stated philosophical perspective and the research methodology?	□	□	□	□
2.	Is there congruity between the research methodology and the research question or objectives?	□	□	□	□
3.	Is there congruity between the research methodology and the methods used to collect data?	□	□	□	□
4.	Is there congruity between the research methodology and the representation and analysis of data?	□	□	□	□
5.	Is there congruity between the research methodology and the interpretation of results?	□	□	□	□
6.	Is there a statement locating the researcher culturally or theoretically?	□	□	□	□
7.	Is the influence of the researcher on the research, and vice-versa, addressed?	□	□	□	□
8.	Are participants, and their voices, adequately represented?	□	□	□	□
9.	Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	□	□	□	□
10.	Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	□	□	□	□

Overall appraisal: Include □ Exclude □ Seek further info □

Adapted from: Lockwood C, Munn Z, Porritt K. Qualitative research synthesis: methodological guidance for systematic reviewers utilizing meta-aggregation. Int J Evid Based Healthc. 2015;13(3):179–187.

Supplemental Table S6: JBI Critical Appraisal Checklist for Quasi-Experimental (Non-Randomized Experimental) Studies.

		Yes	No	Unclear	Not applicable
1.	Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?	□	□	□	□
2.	Were the participants included in any comparisons similar?	□	□	□	□
3.	Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	□	□	□	□
4.	Was there a control group?	□	□	□	□
5.	Were there multiple measurements of the outcome both pre and post the intervention/exposure?	□	□	□	□

6. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	□	□	□	□
7. Were the outcomes of participants included in any comparisons measured in the same way?	□	□	□	□
8. Were outcomes measured in a reliable way?	□	□	□	□
9. Was appropriate statistical analysis used?	□	□	□	□

Overall appraisal: Include □ Exclude □ Seek further info □

Adapted from: Tufanaru C, Munn Z, Aromataris E, Campbell J, Hopp L. Chapter 3: Systematic reviews of effectiveness. In: Aromataris E, Munn Z (Editors). JBI Manual for Evidence Synthesis. JBI, 2020. Available from https://synthesismanual.jbi.global

Supplemental Table S7: JBI Critical Appraisal Checklist for Analytical Cross-sectional studies.

First Author (Year of Publication)	Scored Questions								Total Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	
Asif et al. (2015) [4]		1	1	1	1	1	1	1	7/8
Asif et al. (2017) [5]	1	1	1	1	1	1	1	1	8/8
Morrison et al. (2020) [6]	1	1	1	1	1		1	1	7/8
Schurink et al (2017) [7]	1	1	1	1	1		1	1	7/8
Solberg et al. (2012) [8]		1	1	1	1		1	1	7/8
Tischer et al. (2016) [9]	1	1	1	1			1	1	7/8

Supplemental Table S8: JBI Critical Appraisal Checklist for Qualitative Research.

First Author (Year of Publication)	Scored Questions										Total Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	
Asif et al. (2015) [10]	1	1	1	1	1			1	1	1	8/10

Supplemental Table S9: JBI Critical Appraisal Checklist for Quasi-Experimental (Non-Randomized Experimental) Studies.

First Author (Year of Publication)	Scored Questions									Total Score
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	
Asif et al. (2014) [1]	**1**	**1**	**1**	**1**		**1**	**1**	**1**	**1**	**8/9**

Supplemental Table S10. Psychological outcomes reported among athletes before, during, and after screening

Author (Year of Publication)	Psychometric instrument(s) used	Psychological outcomes		
		Before screening	**During screening**	**After screening**
Asif et al. (2014) [1]	- Prescreen and postscreen self-administered questionnaires (psychometric parameters measured using binary response variable or a 5-point Likert scale: lowest=–2, highest=+2)	- 4.4% worried about cardiac condition - Athletes screened with ECG (and physical/history) were more worried about having cardiac condition than those who were screened without ECG (5.0% vs. 1.4%; p<0.001) - 73% preferred to know of abnormality before competing	- Both groups reported no measurable anxiety during screening, although athletes screened with ECG were more anxious than those screened without ECG (mean=–0.22 vs. mean=–0.8; p<0.001)	- Athletes screened with or without ECG reported no measurable anxiety after screening (mean=−0.85 vs. mean=−0.99; p=0.88)
Asif et al. (2015) [4]	- Prescreen and postscreen self-administered questionnaires (psychometric parameters measured using binary response variable or a 5-point Likert scale: lowest=–2, highest=+2)	- 4.2% worried about cardiac condition - 74% preferred to know of abnormality before competing	- Athletes who screened normal and those who had a FP diagnosis reported no measurable anxiety during screening (mean=–0.29 [SD=1.04] vs. mean=–0.22 [SD=1.18]; p=0.69) - Athletes who had a TP diagnosis reported measurable anxiety during screening (mean=0.08 [SD=1.24])	- Athletes who screened normal and those who had a FP diagnosis reported no measurable anxiety after screening (mean=–0.82 [SD=0.89] vs. mean=–0.94 [SD=1.03]; p=0.36) - Athletes who had a FP diagnosis felt safer during competition compared to those who screened normal (mean=0.75 [SD=1.01] vs. mean=0.48 [SD=0.88]; p<0.001) - Athletes who had a TP diagnosis reported measurable anxiety after screening (mean=0.58 [SD=1.17]) - 75% of athletes who had a TP diagnosis were satisfied with ECG screening and would recommend to others
Asif et al. (2015) [10]	- Semi-structured interviews conducted >6 months after cardiac	- NR	- NR	- Four stages of psychological impact after diagnosis by screening were identified: 1) immediate reaction and

		diagnosis by screening (thematic analysis using consensual qualitative research methods by multiple sports psychology experts)					challenge to athlete identity, 2) grief and coping, 3) adaptation, and 4) acceptance - All athletes had positive attitude towards screening (including ECG) and would repeat and recommend to others
Asif et al. (2017) [5]	-	Prescreen and postscreen self-administered questionnaires (psychometric parameters measured using binary response variable or a 5-point Likert scale: lowest=–2, highest=+2)	- 4.5% worried about cardiac condition - 70.1% prefer to know of abnormality before competing	-	Athletes who screened normal and those who had a FP diagnosis reported no measurable anxiety during screening (normal mean=–0.774, FP mean=–0.594; p=0.369).	-	Athletes who screened normal and those who had a FP diagnosis reported no measurable anxiety after screening (normal mean=–1.054, FP mean=–0.750; p=0.135).
Morrison et al. (2020) [6]	-	Self-administered questionnaire >6 months after cardiac diagnosis by screening (psychological parameters measured using the 22-item IES-R scored on a 5-point Likert scale: lowest=0, highest=4; total sum score out of 88) *	- NR	-	NR	-	Total IES-R scores were normal (median=2.0, [IQR 0-6.0]) - 93% satisfied with screening - 74.6% would recommend screening to others - 44.8% feel safer when exercising after screening - 33% strongly feared sport restriction after diagnosis
Schurink et al. (2017) [7]	-	Self-administered questionnaire >6 months after screening (psychological parameters	- 8.0% experienced measurable anxiety before screening (95% CI 5.0–12%)	-	5.0% experienced measurable anxiety during screening (95% CI 2–8%)	-	Total IES scores were normal (median=1, [IQR 0-2]) - Athletes diagnosed with CAD more likely to feel anxious directly after receiving result (27.1% vs.3.1%; p<0.001)

		measured using the 7-item intrusion sub-scale of the IES graded on a 6-point Likert scale: lowest=0, highest=5; total sum score out of 35) †				-	IES scores significantly higher in participants diagnosed with CAD compared to those who were not (CAD median=1, vs no-CAD median=2; p<0.001) - Majority were satisfied with participation (93.8%, 95% CI 91-97%)
Solberg et al. (2012)[8]	-	Self-administered questionnaire 2-3 months after screening but before knowledge of results (psychological parameters measured using the 7-item intrusion sub-scale of the IES graded on a 6-point Likert scale: lowest=0, highest=5; total sum score out of 35) †	- NR	-	NR	-	Low distress after screening (median IES intrusion score=1, SD=4.8, range=0-30). - 2.8% significant psychological distress (IES intrusion sum score≥19). - Athletes who experienced significant psychological distress would more often recommend screening to others (100% vs. 83%, p≤0.006) - 64% more confident when competing - 88% happy with screening - 84% strongly recommend screening - 16% afraid screen might have consequences to their health
Tischer et al. (2016) [9]	-	Prescreen and postscreen self-administered questionnaires (psychological parameters measured using scales 1-7 of the REST-Q 76 Sport questionnaire graded on a 7-point Likert scale: lowest=0, highest=6) ‡	- Mean scores related to psychological distress before screening were low for both negative and positive screened athletes (general stress: negative=0.84, positive=0.65, p=0.03; emotional stress: negative=1.12, positive=0.99, p=0.23; social stress: negative=2.00, positive=1.84, p=0.13)	-	NR	-	Mean scores related to psychological distress after screening were low for both negative and positive screened athletes (general stress: negative=0.72, positive=0.68, p=0.34; emotional stress: negative=1.00, positive=0.91, p=0.62; social stress: negative=1.82, positive=1.62, p=0.05)

CAD = Coronary Artery Disease, ECG = Electrocardiogram, FP = False Positive, IES = Impact of Event Scale, IES-R = Impact of Event Scale-Revised, NR = not reported, REST-Q 76 Sport = Recovery-stress Questionnaire for Athletes, TP = True Positive

* The IES-R is a 22-item validated tool used to assess an individual's psychological response to traumatic experience. Responses are scored on a 5-point Likert scale (lowest=0, highest=4). Total IES-R scores range from 0 to 88 (<12=no significant stress/normal, 12-32=recommended monitoring, >33=significant stress reaction).
† The intrusion subscale of the IES is a 7-item validated tool commonly applied to measure the level of psychological distress after an event. Responses are scored on a 6-point scale (lowest=0, highest=5). Total IES intrusion scores range from 0 to 35 (>19=clinically significant level of distress).
‡ The REST-Q 76 Sport is a 76 item and 19-scale validated tool to detect stress in athletes. Responses are scored on a 7-point Likert scale (lowest=0, highest=6).

Supplemental Table S11. Expanded key findings among included studies

Author (Year of Publication)	Study methods and variables	Main Findings
Asif et al. (2014) [1]	- 2 screening groups: (control) History and physical exam only, (experimental) History, physical exam, and ECG. - Pre- and post-screen psychological assessments administered to measure health attitudes, anxiety, and impact of screening on sport (Likert scale: -2–2).	- Prior to screening 4.4% were worried about having a cardiac condition and 73% preferred to know if they had an abnormality before competing. - Both the ECG (experimental) and no-ECG (control) groups reported no significant anxiety during screening (control group mean=–0.8 [SD=1.02], experimental group mean=–0.22 [SD=1.10], p<0.001) and there was no significant difference in distress levels immediately after screening (control group mean=−0.99, [SD=0.94], experimental group mean=−0.85 [SD=0.91], p=0.88). - Those who received an ECG during their screening protocol were more satisfied with the screening process (p<0.001), felt safer during competition (p<0.01), were more supportive of cardiovascular screening in athletes (p<0.001), and stated that ECG screening positively impacted their training (p<0.001). - Compared to the no-ECG group, individuals with false positive screening results reported no difference in post-screen anxiety (p=0.775), felt safer during competition (p<0.001), would recommend ECG screening to others (p<0.001), and expressed a positive impact on their training (p<0.001). - Athletes who screened true positive (n=6) did describe anxiety during (mean=0.5, SD=1.05) and after (mean=0.14, SD=1.47) screening, however, they were still satisfied with their cardiovascular screening process (mean=0.67, SD=1.03) and would recommend ECG screening to other athletes (mean=1.5, SD=0.55).
Asif et al. (2015) [4]	- Pre- and post-screen psychological assessments administered to evaluate experiences, health attitudes, anxiety, and impact of screening on sport (Likert scale: -2–2).	- Before screening only 4.2% were worried about having a cardiac condition and 74% preferred to know about a possible cardiovascular disorder before competing. - Athletes screening either normal or false positive reported no measurable anxiety, with no significant difference in distress between these groups both during (normal mean=–0.29, SD=1.04; FP mean=–0.22, SD=1.18, p=0.69) and after screening (normal mean=–0.82, SD = 0.89; FP =–0.94, SD = 1.03; p= 0.36). - 92% of athletes who underwent screening would recommend cardiovascular screening including ECG to other young athletes.

		- After screening, athletes who screened false positive (n=333) described feeling safer during competition compared to those who had normal screens (FP mean=0.75, SD = 1.01; normal mean=0.48, SD = 0.88; p<0.001). - Athletes with a true positive screen (n=13) reported anxiety both during (mean=0.08, SD = 1.24) and after (mean=0.58, SD=1.17) screening, but 75% of these athletes were still satisfied ECG screening and would recommend it to others. - When analyzed by subgroup, there were no significant differences in anxiety during (younger mean=–0.22, SD=1.09; older mean=–0.32, SD=1.06) or after (younger mean=–0.77, SD=0.96; older mean=–0.86, SD=0.91) screening in the younger age (13-15) and older age (16-18) cohorts, with both of these age groups reporting ECG screening having a positive impact on their training (younger=90%, older=92%). - African American athletes were significantly less worried about having an underlying cardiac condition (mean=–1.47, SD=0.82; p<0.001) and less concerned that their screen would be abnormal (mean=–1.09, SD=0.99; p<0.001) compared to white athletes (worried=–1.16, SD=0.88; concerned=–0.68, SD=1.00). - Males were significantly less concerned that their screening would be abnormal (males=–0.89, SD=1.00; females=–0.63, SD=1.00; p<0.001 and were less distressed during screening (males=–0.35, SD=1.09; females=–0.16, SD=1.06; P<0.01) compared to females.
Asif et al. (2015) [10]	- Sports psychology experts analyzed semi-structured interviews with athletes diagnosed with cardiac conditions by screening using qualitative research.	- Competitive high school and collegiate athletes progress through four successive stages of psychological impact after being diagnosed with a cardiac condition by cardiovascular screening: 1) immediate reaction and challenge to athlete identity, 2) grief and coping, 3) adaptation, and 4) acceptance. - All athletes (n=25) had an overall positive attitude towards screening (including ECG) and reported that they would repeat screening and recommend it to others, despite the challenges they faced due to their diagnosis. - Risk factors associated with increased or prolonged psychological morbidity included higher level of competition (collegiate>high school), disqualification from sport (vs. temporary restriction), unanticipated outcomes, or persistent reminders of an underlying disease.
Asif et al. (2017) [5]	- Pre- and post-screen psychological assessments administered to evaluate experiences, health attitudes, anxiety, and impact of screening on sport (Likert scale: -2–2).	- Prior to screening 4.5% were worried about having an underlying cardiac disorder and 70.1% reported they would rather know about the disorder before competition. - Athletes who screened normal (n=1098) or false positive (n=34) reported no measurable anxiety during (normal=–0.774, FP=–0.594) and after (normal=–1.054, FP=–0.750) screening. - There were no statistically significant differences in anxiety during screening across gender (male=−0.788 vs. female −0.727), race (Caucasian=−0.769 vs. African–American), collegiate athletic division (division I=−0.716 vs. division II=−0.820, vs. division III=−0.761), or sport (baseball=−0.576 vs. basketball=−0.642, cross-country/track=−0.813 vs. football=−0.861 vs. soccer=−0.721 vs. swimming=−0.671 vs. rowing=−0.855). - Athletes with false positive screening results were more concerned about potential for sports disqualification (normal=−0.734 vs. FP=0.241, p<0.001), but were significantly more likely to feel that all athletes should receive an ECG prior to athletic competition (FP=1.156 vs. normal=0.824, p<0.01) and to feel safer during athletics (FP=0.719 vs. normal=0.185, p<0.01).

Morrison et al. (2020) [6]	- Masters athletes diagnosed with a cardiac condition by screening were surveyed to assess experiences of psychological distress (Impact of Event Scale-Revised [IES-R] and Likert scale: 0–4).	- After preparticipation screening, total IES-R scores were normal (median=2.0, [IQR 0-6.0]), with only 1 participant eliciting a significant stress reaction (IES-R=37) and none meeting the criteria for depression. - Males had significantly higher IES-R scores than female athletes (male median=3.0, [IQR 0-6.5] vs female median=0, [IQR 0-0.5]; p=0.033). - 93% of athletes were satisfied with cardiovascular preparticipation screening and 74.6% would recommend it to others. - 44.8% of these athletes reporting feeling safer when exercising after their screening diagnosis, whereas 26.9% felt slightly less safe. - 33% of athletes strongly feared sport restriction after their diagnosis. - 94% of participants reported that the follow-up provided was adequate to understand their diagnosis, however 72% described additional types of desired support including more time with a cardiologist (28.4%), follow-up with a general practitioner (22.4%), and/or follow-up with a dietician (16.4%).
Schurink et al (2017) [7]	- Masters athletes underwent a cardiovascular PPS protocol including cardiac CT. - Psychological impact was measured using the Impact of Events Scale (IES) and a Likert Scale (0–5) was used to evaluate overall experiences and impact on sports and lifestyle.	- Total IES scores were normal (median=1, [IQR 0-2]), with only 1 participant experiencing clinically significant psychological distress after screening (IES sum score≥19). - IES scores were significantly higher in participants diagnosed with coronary artery disease (CAD) compared to those who were not (CAD median=1, mean rank=175 vs no-CAD median=2, mean rank=130; p<0.001). - Very few participants experienced anxiety before (8.0%, 95% CI 5–12%) or during (5.0%, 95% CI 2–8%) screening involving CT scanning, and no significant differences were seen between those diagnosed with CAD and those who were not. - Participants found to have CAD were more often felt anxious directly after receiving the result (27% vs. 3.0%, p<0.001), were afraid of being advised to quit sports (21% vs. 3.0%, p<0.001) and held the opinion they were at higher risk of a cardiac condition than other master's athletes (23% vs. 4.0%, p<0.001). - Generally, masters athletes agreed that screening had a positive influence on sporting activities, with only 5.5% (95% CI 3.0-8.0%) disagreeing and 35% (95% CI 53-65%) holding a neutral opinion. - Majority of athletes (59%, 95% CI 53-65) felt safer exercising after screening, whereas 32% (95% CI 26-38%) experienced no difference and 9.4% (95% CI 6.0-13%) felt less safe exercising. - Those screening true positive and receiving a CAD diagnosis after screening more often felt that cardiovascular preparticipation screening was needed in master's athletes without CAD (88% vs. 68%, p=0.007). - The vast majority of participants were satisfied with their screening (94%, 95% CI 91-97%), would participate in screening again (95%, 95% CI 92-97%), and would recommend screening to others (93%, 95% CI 90-96%).
Solberg et al. (2012) [8]	- After screening, athletes completed a 10-item scale assessing their experience (Likert scale: 0–5). - Psychological distress after screening was	- The degree of distress caused by cardiovascular preparticipation screening was low (median IES score=1, SD=4.8, range=0-30). - Only 2.8% of athletes experienced clinically significant psychological distress (IES sum score≥19) due to screening. These athletes would more often recommend screening to others (100% vs. 83%, p≤0.006). - After screening, 64% of athletes reported feeling more confident when competing, 88% were happy they underwent screening, and 84% stated they would strongly recommend it to others.

	measured with the Impact of Event Scale (IES).	- 16% of athletes were afraid their screen might have consequences to their health and 13% were afraid of losing their license to play.
Tischer et al. (2016) [9]	- Athletes completed a questionnaire assessing stress level immediately prior to screening, immediately after screening, and 3 days after screening. - The REST-Q 76 Sport was used as a validated tool to detect stress in athletes, with each of 76 subscales scored on a Likert scale (0–6).	- The majority of participants screened negative for all forms of psychological morbidity on the REST-Q Sport questionnaire after undergoing cardiovascular preparticipation screening including ECG and echocardiography. - Out of responding athletes, 88% screened negative for general stress, emotional stress, and social stress before screening and 90% screened negative 3 days after screening. - Among athletes referred for additional testing after their initial screen, these individuals reported lower levels of stress at both examination day and 3 days after. - A tendency towards a decrease in stress is observed after athletes undergo preparticipation screening, however this decrease is only statistically significant in those who screen negative.

Supplemental Table S12. Summary measures among studies reporting psychological outcomes stratified by screening result.

Psychological Outcome	Median Likert score (1 - 5) *			Number of Eligible Studies	N	Median (%)			Number of Eligible Studies	N
	N	FP	TP			N	FP	TP		
Before Screening										
Psychological distress †	1.87	1.94	-	1	1,192	7.9%	-	10.4%	1	275
During Screening										
Psychological distress †	2.71	2.78	3.29	3	3,660	5.7%	-	2.1%	1	275
After Screening										
Psychological distress †	2.18	2.06	3.36	3	3,660	3.1%	-	27%	1	275
Feel safer during sport	3.44	3.72	-	3	3,660	60%	-	54%	1	275
Positive impact on training	3.82	3.80	-	3	3,660	60%	-	63%	1	275
Satisfied with screening	4.34	4.21	3.75	3	3,660	93%	-	98%	1	275
Recommend screening to other athletes	4.32	4.35	4.46	3	3,660	92%	-	98%	1	275

* Likert scale values reported under Median Likert Score and Range of Likert Scores reflect sample mean values reported amongst each eligible study.
† Psychological distress is a composite measure describing all outcomes pertaining to athletes' self-reported distressing emotions (i.e., anxiety, worry, intrusion, fear) regarding cardiovascular preparticipation screening.
‡ Median (%) reflect the results of a single study reporting psychological outcomes stratified by screening result in proportions [4].

Supplemental Appendix A1. Detailed description of how findings of each study were modified to produce the summary measures in this review.

Summary measures (median, range) for each psychological outcome were computed across included studies. Although most studies assessed psychological outcomes using a 5-point Likert scale ranging from a score of –2 (worst) to 2 (best), some studies used a scaling system of 0 to 4 or 1 to 5, while other studies used a 6-point Likert scale ranging from 0 to 5 and or a 7-point Likert scale from 0-6. For clarity and consistency in reporting summary measures in this systematic review, the mean Likert score reported by or calculated from each study was standardized to a 5-point Likert scale ranging from 1 (worst) to 5 (best). Measures already reported using a 5-point scale were simply adjusted to range from 1 to 5, whereas measures reported on 6- or 7-point scales were adjusted to a 1 to 5 scale using previously validated methodology [11]. Among studies which did not provide a mean measurement for the cohort and instead only provided mean measurements for subgroup, an overall sample mean was produced by calculating the weighted mean amongst all subgroups in the study cohort. Due to heterogeneity in reporting amongst included studies, summary measures for both Likert scale ratings and proportions were produced.

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