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.

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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

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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

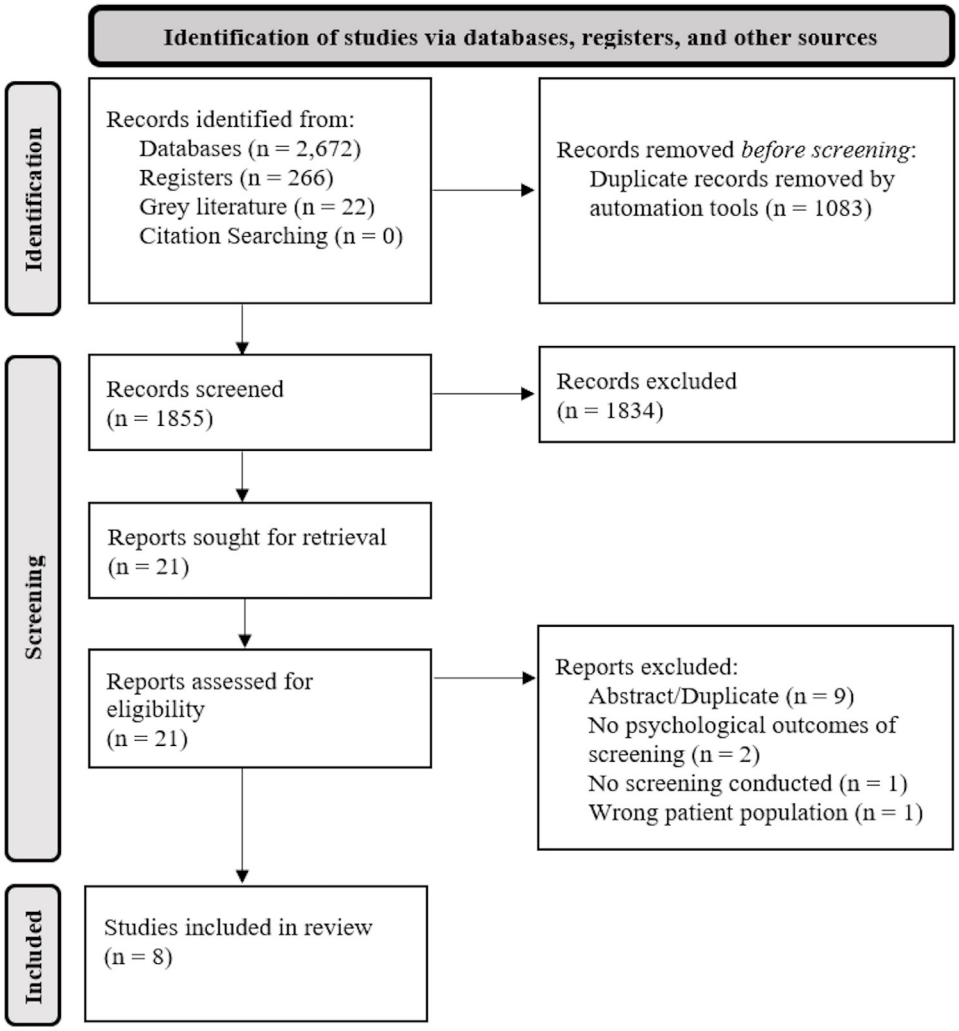

Figure 1 PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) study selection flow chart.

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

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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REFERENCES

1 Asif IM, Drezner JA. Cardiovascular screening in young athletes: evidence for the electrocardiogram. *Curr Sports Med Rep* 2016;15:76–80.
2 Grubic N, Hill B, Phelan D, *et al*. Bystander interventions and survival after exercise-related sudden cardiac arrest: a systematic review. *Br J Sports Med* 2022;56:410–6.
3 Johri AM, Poirier P, Dorian P, *et al*. Canadian cardiovascular Society/Canadian heart rhythm Society joint position statement on the cardiovascular screening of competitive athletes. *Can J Cardiol* 2019;35:1–11.
4 Grubic N, Puskas J, Phelan D, *et al*. Shock to the heart: psychosocial implications and applications of sudden cardiac death in the young. *Curr Cardiol Rep* 2020;22.
5 Asif IM, Price D, Harmon KG, *et al*. The psychological impact of cardiovascular screening in young athletes: perspectives across age, race, and gender. *Clin J Sport Med* 2015;25:464–71.
6 Maron BJ, Friedman RA, Kligfield P, *et al*. Assessment of the 12-lead ECG as a screening test for detection of cardiovascular disease in healthy general populations of young people (12-25 years of age): a scientific statement from the American heart association and the American College of cardiology. *Circulation* 2014;130:1303–34.
7 Mont L, Pelliccia A, Sharma S, *et al*. Pre-participation cardiovascular evaluation for athletic participants to prevent sudden death: position paper from the EHRA and the EACPR, branches of the ESC. Endorsed by APHRS, HRS, and SOLAECE. *Eur J Prev Cardiol* 2017;24:41–69.
8 Drezner JA, O'Connor FG, Harmon KG, *et al*. AMSSM position statement on cardiovascular preparticipation screening in athletes: current evidence, knowledge gaps, recommendations and future directions. *Br J Sports Med* 2017;51:153–67.
9 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.
10 Lampert R. ECG screening in athletes: differing views from two sides of the Atlantic. *Heart* 2018;104:1037–43.
11 Asif IM, Price D, Fisher LA, *et al*. Stages of psychological impact after diagnosis with serious or potentially lethal cardiac disease in young competitive athletes: a new model. *J Electrocardiol* 2015;48:298–310.
12 Maron BJ, Thompson PD, Ackerman MJ, *et al*. Recommendations and considerations related to preparticipation screening for cardiovascular abnormalities in competitive athletes: 2007 update: a scientific statement from the American Heart Association Council on nutrition, physical activity, and metabolism: endorsed by the American College of cardiology Foundation. *Circulation* 2007;115:1643–455.
13 Ackerman M, Atkins DL, Triedman JK. Sudden cardiac death in the young. *Circulation* 2016;133:1006–26.
14 Muñoz-Bullón F, Sanchez-Bueno MJ, Vos-Saz A. The influence of sports participation on academic performance among students in higher education. *Sport Management Review* 2017;20:365–78.
15 Grubic N, Jain S, Mihajlovic V, *et al*. Competing against COVID-19: have we forgotten about student-athletes' mental health? *Br J Sports Med* 2021;55:950–1.
16 Moulson N, Kuljic N, McKinney J, *et al*. Variation in preparticipation screening medical questionnaires and physical examinations across Canadian universities. *Can J Cardiol* 2018;34:933–6.
17 Page MJ, McKenzie JE, Bossuyt PM. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372.
18 McKinney J, Velghe J, Fee J, *et al*. Defining athletes and Exercisers. *Am J Cardiol* 2019;123:532–5.
19 Haddaway NR, Collins AM, Coughlin D, *et al*. The role of Google scholar in evidence reviews and its applicability to grey literature searching. *PLoS One* 2015;10:e0138237.
20 McKeown S, Mir ZM. Considerations for conducting systematic reviews: evaluating the performance of different methods for de-duplicating references. *Syst Rev* 2021;10:38.
21 Wohlin C. Guidelines for snowballing in systematic literature studies and a replication in software engineering. *ACM International Conference Proceeding Series* 2014.
22 JBI. *The Joanna Briggs Institute Reviewers' Manual 2014: Methodology for JBI Mixed Methods Systematic Reviews*. Joanne Briggs Institute, 2014.
23 Moola S, Munn Z, Tufanaru C. Chapter 7: Systematic Reviews of Etiology and Risk. In: *JBI manual for evidence synthesis*, 2020.
24 Zeng X, Zhang Y, Kwong JSW, *et al*. The methodological quality assessment tools for preclinical and clinical studies, systematic review and meta-analysis, and clinical practice guideline: a systematic review. *J Evid Based Med* 2015;8:2–10.
25 McKenzie JE, Brennan SE. Chapter 12: Synthesizing and presenting findings using other methods. In: *Cochrane Handbook for systematic reviews of interventions version 60*. Cochrane Training, 2019.
26 Ridner SH. Psychological distress: concept analysis. *J Adv Nurs* 2004;45:536–45.
27 Drapeau A, Marchand A, Beaulieu-Prévost D. Epidemiology of Psychological Distress. In: *Mental Illnesses - Understanding, Prediction and Control*. IntechOpen, 2012.
28 Fleiss JL, Levin B, Paik MC. The measurement of interrater agreement. In: *Statistical methods for rates and proportions*, 2004: 598–626.
29 Asif IM, Annett S, Ewing JA, *et al*. Psychological impact of electrocardiogram screening in national collegiate athletic association athletes. *Br J Sports Med* 2017;51:1489–92.

30 Morrison BN, Zwaiman I, Isserow S, *et al*. Masters athlete screening study (mass): insights into the psychological impact of cardiovascular Preparticipation screening. *Clin J Sport Med* 2021;31:494–500.
31 Schurink MM, Braber TL, Prakken NHJ, *et al*. No psychological distress in sportsmen aged 45 years and older after cardiovascular screening, including cardiac CT: the measuring athlete's risk of cardiovascular events (MARC) study. *Neth Heart J* 2017;25:271–7.
32 Drezner JA, Sharma S, Baggish A, *et al*. International criteria for electrocardiographic interpretation in athletes: consensus statement. *Br J Sports Med* 2017;51:704–31.
33 Basu J, Malhotra A. Interpreting the athlete's ECG: current state and future perspectives. *Curr Treat Options Cardiovasc Med* 2018;20:104.
34 Hyde N, Prutkin JM, Drezner JA. Electrocardiogram interpretation in NCAA athletes: Comparison of the 'Seattle' and 'International' criteria. *J Electrocardiol* 2019;56:81–4.
35 Malhotra A, Dhutia H, Yeo T-J, *et al*. Accuracy of the 2017 international recommendations for clinicians who interpret adolescent athletes' ECGs: a cohort study of 11 168 British white and black soccer players. *Br J Sports Med* 2020;54:739–45.
36 Petek BJ, Drezner JA, Prutkin JM, *et al*. Electrocardiogram interpretation in college athletes: local institution versus sports cardiology center interpretation. *J Electrocardiol* 2020;62:49–56.
37 Piepoli MF, Hoes AW, Agewall S, *et al*. 2016 European guidelines on cardiovascular disease prevention in clinical practice: The sixth joint task force of the European Society of Cardiology and other societies on cardiovascular disease prevention in clinical practice (constituted by representatives of 10 societies and by invited experts)Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). *Eur Heart J*2016;37.
38 Riba MB, Donovan KA, Andersen B. Distress management, version 3.2019. *J Natl Compr Canc Netw* 2019;17:1229–49.
39 Solberg EE, Bjørnstad TH, Andersen TE, *et al*. Cardiovascular pre-participation screening does not distress professional football players. *Eur J Prev Cardiol* 2012;19:571–7.
40 Tischer SG, Mattsson N, Storgaard M, *et al*. Results of voluntary cardiovascular examination of elite athletes in Denmark: proposal for Nordic collaboration. *Scand J Med Sci Sports* 2016;26:64–73.
41 Martin LA, Fogarty GJ, Albion MJ. Changes in athletic identity and life satisfaction of elite athletes as a function of retirement status. *J Appl Sport Psychol* 2014;26:96–110.
42 Etheridge SP, Saarel EV, Martinez MW. Exercise participation and shared decision-making in patients with inherited channelopathies and cardiomyopathies. *Heart Rhythm* 2018;15:915–20.
43 Asif IM, Price DE, Ewing A, *et al*. The impact of diagnosis: measuring the psychological response to being diagnosed with serious or potentially lethal cardiac disease in young competitive athletes. *Br J Sports Med* 2016;50:163–6.
44 Luiten RC, Ormond K, Post L, *et al*. Exercise restrictions trigger psychological difficulty in active and athletic adults with hypertrophic cardiomyopathy. *Open Heart* 2016;3:e000488.
45 Reardon CL, Hainline B, Aron CM, *et al*. Mental health in elite athletes: international Olympic committee consensus statement (2019). *Br J Sports Med* 2019;53:667–99.
46 Gouttebarge V, Bindra A, Blauwet C, *et al*. International Olympic Committee (IOC) sport mental health assessment tool 1 (SMHAT-1) and sport mental health recognition tool 1 (SMHRT-1): towards better support of athletes' mental health. *Br J Sports Med* 2021;55:30–7.
47 Chang C, Putukian M, Aerni G, *et al*. Mental health issues and psychological factors in athletes: detection, management, effect on performance and prevention: American medical Society for sports medicine position Statement-Executive summary. *Br J Sports Med* 2020;54:216–20.
48 Durand-Bush N, van Slingerland K. Mental health and sport in Canada : An example of sport-focused collaborative care. In: *Mental health in elite sport*, 2021: 80–91.
49 Van Slingerland KJ, Durand-Bush N, Bradley L, *et al*. Canadian centre for mental health and sport (CCMHS) position statement: principles of mental health in competitive and high-performance sport. *Clin J Sport Med* 2019;29:173–80.
50 Reardon CL, Bindra A, Blauwet C, *et al*. Mental health management of elite athletes during COVID-19: a narrative review and recommendations. *Br J Sports Med* 2021;55:608–15.
51 Deslandes A, Moraes H, Ferreira C, *et al*. Exercise and mental health: many reasons to move. *Neuropsychobiology* 2009;59:191–8.
52 De Hert M, Detraux J, Vancampfort D. The intriguing relationship between coronary heart disease and mental disorders. *Dialogues Clin Neurosci* 2018;20:31–40.
53 Assouline-Reinmann M, Chytas V, Coen M, *et al*. [Psychological health and cardiovascular disease : interdependency and therapeutic opportunities]. *Rev Med Suisse* 2021;17:1015–20.
54 Ruegsegger GN, Booth FW. Health benefits of exercise. *Cold Spring Harb Perspect Med* 2018;8. doi:10.1101/cshperspect.a029694. [Epub ahead of print: 02 07 2018].
55 De Sousa RAL, Improta-Caria AC, Aras-Júnior R, *et al*. Physical exercise effects on the brain during COVID-19 pandemic: links between mental and cardiovascular health. *Neurol Sci* 2021;42:1325–34.
56 McNaughton-Collins M, Fowler FJ, Caubet J-F, *et al*. Psychological effects of a suspicious prostate cancer screening test followed by a benign biopsy result. *Am J Med* 2004;117:719–25.
57 Brewer NT, Salz T, Lillie SE. Systematic review: the long-term effects of false-positive mammograms. *Ann Intern Med* 2007;146:502–10.
58 Podsakoff PM, MacKenzie SB, Lee J-Y, *et al*. Common method biases in behavioral research: a critical review of the literature and recommended remedies. *J Appl Psychol* 2003;88:879–903.
59 Zorzi A, Cardaioli F, Cipriani A, *et al*. Impact of exercise addiction on attitude to preparticipation evaluation and adherence to medical prescription. *J Cardiovasc Med* 2020;21:772–8.