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Have National Collegiate Athletic Association Institutions Increased the Number of American Heart Association Recommendations for Cardiac Screening?

Jennifer R. Street

Thesis submitted to the
School of Physical Education
at West Virginia University in
partial fulfillment of the requirements
for the degree of

Master of Science
In
Athletic Training

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Key words: sudden cardiac death, American Heart Association, Collegiate athletes, pre-participation physical examination

ABSTRACT

Have National Collegiate Athletic Association Institutions Increased the Number of American Heart Association Recommendations for Cardiac Screening?

Jennifer R. Street, ATC

Context: Sudden cardiac death among young competitive collegiate athletes has heightened interest in cardiovascular pre-participation screening in colleges and universities. *Objective:* The purpose of the study was to identify the cardiovascular screening protocols among National Collegiate Athletic Association (NCAA) Division I, II, and III institutions in accordance with the recommended American Heart Association (AHA) guidelines. *Design:* The design of this study was a prospective descriptive analysis, which identified the cardiovascular screening and use of the recommended American Heart Association guidelines by surveying Division I, II, and III National Collegiate Athletic Association institutions. *Setting:* National Collegiate Athletic Association Division I, II, and III institutions. *Participants:* This study included the head athletic trainers or director of athletic training services at 330 Division I, 293 Division II, and 445 Division III institutions for a total of 1068. This was a sample of convenience by including every NCAA institution in each Division. The subjects that are included were used because of their primary role with pre-participation physical examinations. The subjects that were excluded are certified athletic trainers that are not employed by NCAA Division I, II, and III institutions. *Intervention:* The subjects completed an electronic survey via email. The email directed the subjects to the website providing the consent by submission of the survey. Each section included demographics, pre-participation examination, medical history, physical examination, and referral. After a two week period a second email was sent encouraging participants to complete the survey. *Main Outcome Measures:* Based on the responses the majority of NCAA Division I, II, and III institutions performed a cardiac screening within their pre-participation physical examination. NCAA Division I include the majority of medical history and physical examination questions within their cardiovascular screening. Based on the responses NCAA Division III improved the most on implementation of the recommended American Heart Association guidelines within their cardiac screening from the previous study performed in 2000. *Results:* A total of 327 head certified athletic trainers and director of athletic training services completed the survey responding to cardiovascular screening for a return rate of 33.5 percent. Of those, 103 (31.5%) NCAA Division I, 91 (27.8%) NCAA Division II, and 133 (40.7%) NCAA Division III institutions. The mean score of undergraduate student enrollment was 7562.70 ± 9146.915, student athletes 372.08 ± 173.942, and number of varsity sports was 17.12 ± 14.263. Of the responses a total of 172(52.6%) were aware of the NCAA recommendations with 74(71.8%) Division I, 44(48.4%) Division II, and 54(40.6%) Division III. A total of 322(98.5%) of NCAA institutions perform a cardiovascular screening within their pre-participation physical examination. NCAA institutions that performed yearly pre-participation physical examinations were 186(56.9%). One hundred eighty seven (27.2%) team physicians administered the tests, with 206(63%)

specializing in general medicine. Other professionals that assist in pre-participation physical examinations are certified athletic trainers (n=257,78.6%), athletic training students (n=135,41.3%), team physicians (n=147,45%), and physical therapists (n=34,10.4%). Results from the 3 x 3 Chi-Square contingency table indicted that there was a significant difference (χ^2=11.429, P=.022) between NCAA Division and the inclusion of the recommended AHA guidelines assessing from inadequate, moderate, and adequate. A total of 327(45%) NCAA institutions were found to be adequate including 9 of the 12 AHA recommendations with Division I (n=103,55.3%), Division II (n=91,48.4%), and Division III (n=133,34.6%). NCAA institutions judged to be inadequate with 4 or less of the AHA recommendations were (n=327,7%) with Division I (n=103,4.9%), Division II (n=91,5.5%) and Division III (n=133,9.8%). *Conclusion:* This study was designed for the purpose of describing and comparing cardiovascular screening procedures with the recommended 1996 American Heart Association guidelines within NCAA Division I, II, and III institutions. The responses represent the practices of head certified athletic trainers at NCAA Division I, II, and III institutions. Based on the hypotheses in regards to the responses and the results of the Chi-Square all were accepted with implementation of the recommended American Heart Association guidelines. This study indicated that NCAA institutions have increased the number of recommendations of American Heart Association guidelines used for cardiovascular screening of collegiate athletes. When the recommended AHA guidelines were used for comparison, only 7 percent of the NCAA institutions were considered to have inadequate screening forms. This is encouraging, indicating that these NCAA institutions recognize the importance of cardiovascular screenings within pre-participation physical examinations. The continual improvement of screening with implementation of the recommended AHA guidelines and recognition of cardiovascular conditions by the certified athletic trainers and sports medicine professionals has the potential to reduce the rate of sudden cardiac death among collegiate athletes.

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INTRODUCTION

In past several years there has been increasing interest and concern in the medical and lay communities about sudden and unexpected deaths in young trained athletes. The risks associated with participation in organized competitive sports are diverse, ranging from sudden collapse due to various underlying cardiovascular disease to death from non-penetrating chest impact.[1-7] Interest in athletic field deaths has also accelerated because of the recognition that these catastrophic events are probably more common than previously thought, may occur in athletes of both genders and all races, and that the responsible structural cardiovascular diseases may be clinically identifiable.[4,5,8-14]

Sudden cardiac death in young athletes is rare. The exact prevalence is not known as a national database to track the death of athletes in nonexistant.[4,5,8-14] The available studies estimate the incidence among high school and collegiate athletes to be between 1 per 100,000 and 1 per 300,000, respectively, each year.[4,5,8-14] An estimated number of 50 to 100 cases occur in young athletes annually in the United States.[4,5,8-14] Despite the overall low incidence of sudden cardiac death within the population, it represents 30 percent of all non-traumatic deaths, with one third of victims younger than 65 years.[4,5,8-14] Eighty percent of sudden cardiac death cases in young athletes occur either during or immediately after strenuous exercise.[4,5,8-14] This suggests that physical activity may be a trigger for cardiac arrhythmias in those with certain cardiac disease.

Sudden cardiac death is an umbrella of diseases consisting of the most common and the least common diseases. The most common diseases that occur in young athletes are hypertrophic cardiomyopathy accounting for at least 36 percent of deaths and congenital coronary artery anomalies at 19 percent.[6,13,15] The less common diseases are

arrhythmogenic right ventricular dysplasia, myocarditis, Marfan syndrome, long QT-syndrome, mitral valve prolapse, commotion cordis, Wolff-Parkinson-White syndrome, and Brugada syndrome.[4,5,8-14]

Thousands of young competitive athletes receive a pre-participation physical examination (PPE) each year in the United States. Included in the PPE are medical history questions and physical examinations for orthopedic and medical conditions. One of the objectives of the PPE is to detect underlying cardiovascular abnormalities that may predispose an athlete to sudden cardiac death.[16] Despite the elusive nature of these disorders, a carefully performed cardiovascular history and physical examination including the recommended American Heart Association guidelines pre-participation examinations is imperative.[16-19] Participation eligibility for athletes diagnosed with cardiovascular abnormalities can be judged further using guidelines from the 36th Bethesda Conference consensus panel.[8,20-22]

The American Heart Association (AHA) assembled a panel of experts of physicians and cardiologists in 1996 to develop recommendations and guidelines for cardiovascular screening. These recommendations were developed, in part, as a response to the medical community's increased concern about sudden cardiac death in competitive athletes. The panel of experts included primary care physicians with extensive involvement in sports medicine at the professional, college, and high school levels, and cardiovascular specialists and legal counsel.[17,18,20] The AHA updated their recommendation in 2007 following recommendations by Pfister et al. in 2000 in creating twelve guidelines.[23] The present 2007 AHA recommendations for personal and family history and physical examination are promoted by the panel as a potentially effective

strategy to raise the suspicion of cardiovascular disease in both large and small screening populations of high school and college student-athletes.[21] The 2007 AHA recommendations consist of twelve items (eight for personal and family history and four for physical examination).[21] At the discretion of the examiner, a positive response or finding in any one or more of the twelve items may be judged sufficient to trigger a referral for cardiovascular evaluation.[21]

In contrast to high schools, colleges, and universities usually conduct pre-participation screening within a pre-existing infrastructure. Traditionally, member institutions of the National Collegiate Athletic Association (NCAA) have been independently responsible for their own pre-participation evaluation process and the design of the institutional screening history and physical examination. The NCAA Committee on Competitive Safeguards and Medical Aspects of Sports has mandated a pre-participation evaluation for all collegiate athletes in Division I, II, and III before their first practice or competition. The NCAA also recommends that these evaluations be performed or supervised by a qualified physician on the basis of the cardiovascular recommendations. The NCAA has adopted ten of the twelve recommended history and physical examination items promoted by the AHA, omitting only history of fatigability and Marfan stigmata on examination.[21] The NCAA feels that the ten that are recommended are sufficient in assessing cardiovascular problems among collegiate athletes.

The focus of the examination should seek to rule out historical or physical examination features that have been associated with common causes of sudden death in young athletes. Athletes who demonstrate abnormalities on either the history or the

physical examination warrant a more detailed examination. The early identification of cardiac disease in athletes is, therefore, of the utmost importance, especially because the majority of sudden death cases could be diagnosed antemortem with appropriate screening tests.[10-14,22]

Currently the pre-participation cardiovascular screening process at NCAA Division I, II, and III institutions are not meeting the minimum standards established by the AHA and the NCAA. This is despite the increased focus on sudden cardiac death during the past decade by many in the sports medicine community and numerous publications. Why this occurs may be that AHA standards are only recommendations and not requirements from the NCAA.

Studies performed by Pfister et al. 2000, [23] and Koester 2001,[20] reported that only 26 percent of NCAA schools were found to be using adequate forms. NCAA Division II and Division III were found to have inadequate forms 28 percent and 30 percent, respectively. Although no perfect cardiovascular screening instrument is currently available, a moral and ethical obligation exists for physicians and certified athlete trainers to ensure that athletes are assessed in the most prudent and efficient manner available. Therefore, the recommendations of the AHA should be considered the minimum standard for the cardiovascular screening of collegiate athletes nationwide.

Pre-participation cardiovascular screening of the athletic populations before competition offers the potential to identify asymptomatic athletes with potentially lethal cardiovascular abnormalities and to prevent sudden death through disqualification from competitive sports. Despite the AHA and NCAA recommendations for cardiovascular screenings, NCAA institutions thus far have been inadequate in the cardiovascular

screening process.[20,23] Therefore, the purpose of this study was to determine if NCAA Division I, II, and III institutions have increased from previous studies the number of recommended AHA guidelines into the cardiovascular examination.

METHODS

The design of this study was a prospective descriptive analysis, which identified the NCAA Division I, II, and III institutions' cardiovascular screening and the inclusion of the recommended AHA guidelines. This analysis examined the independent variable of a 24-question survey consisting of demographics, pre-participation exam, medical history, physical examination, and referral. The dependent variable was the responses from the head certified athletic trainer or director of athletic training services from the survey.

Participants

The participants were 330 NCAA Division I, 293 II, and 445 III head certified athletic trainers or the director of athletic training services of each institution. A total of 1068 NCAA institutions were surveyed. Sampling the total number of institutions in each Division eliminates sampling bias and assures an equal number of schools were represented in each geographical location. The participants included in the study were selected using a sample of convenience. Selection of the participants began by starting with the NCAA website so as to be directed to the official athletics website of each institution. From those websites, names and email addresses of the head certified athletic trainer or the director of athletic training services were determined. The participants that were excluded are athletic trainers who are not certified or who do not work in an NCAA

Division I, II, or III athletic department. The study was approved by the Office of Research Compliance, at West Virginia University.

Instrumentation

The pre-participation cardiovascular screening procedure survey consisted of 24-questions including demographics, pre-participation exam information, medical history form, physical exam, and referral. The survey was developed from previous surveys conducted at Division I, II, and III institutions including American Heart Association guidelines and cardiovascular screenings.[20,23] The demographic section described education, certifications, NCAA Division, student enrollment, student-athlete population, and number of intercollegiate sports. The pre-participation exam information examined the frequency, the administration, and physician involvement. The medical history section pertained to the questions that are asked of the student-athlete consisting of family history and personal history. The physical examination section covered the questions that are asked of the student-athlete consisting of physical signs and symptoms of cardiac conditions. Lastly, the referral section included questions to evaluate the institutions referral process.

The survey was reviewed by three certified athletic trainers from NCAA Division I, two certified athletic trainers from Division II, and one certified athletic trainer from Division III for reading and clarity. A psychometric statistical expert experienced in questionnaire/survey writing also viewed the survey for face and content validity.

Procedures

The head certified athletic trainer or director of athletic training services from NCAA Division I, Division II, and Division III institutions was chosen from each

institution athletics website obtained from the NCAA website. All institutions were used to eliminate sampling bias for a total of 1068 NCAA institutions: 330 from Division I, 293 from Division II, and 445 from Division III.

The survey was sent via e-mail to the head certified athletic trainer or the director of athletic training services through West Virginia University using Simple Form. The e-mail consisted of a cover letter explaining what the head certified athletic trainer or director of athletic training services should do if willing to participate. Each of the head certified athletic trainers or director of athletic training services was asked to visit a website where the survey was located. If willing to participate, the head certified athletic trainer or director of athletic training services then typed in their answers to the survey, and returned the completed survey by clicking the submit button. If the head certified athletic trainer or director of athletic training services was not willing to participate, he/she simply did not return the survey to the researchers.

The head certified athletic trainer or director of athletic training services who did not participate within two weeks was contacted a second time and was again asked to participate. The survey was emailed once in the month of October and then two weeks following, which was the last week of October. The data was returned to the researcher via an email that was addressed as anonymous for the confidentiality of the participants. The information that was returned was then put into an Excel spreadsheet for future analysis using Statistical Package for the Social Sciences (SPSS) 14.0, to analyze the data.

The only instrument is a survey that was sent via email to the head certified athletic trainer or director of athletic training services. The online survey was housed on

the university server, which, by using a firewall, protects data in transit from outside observation. The results of each survey was automatically processed by a Common Gateway Interface (CGI) server, which is also protected by the firewall and is accessible only to two university web masters. The data was processed in the working memory of the CGI server and was not stored to disk; after being processed the data no longer exists on the CGI server. The CGI server will automatically send the data via e-mail to the researcher where the information was saved in a locked file. Upon completion of data collection, the spreadsheet was transferred to a Universal Serial Bus (USB) drive that was kept in a locked drawer and the data was then deleted from the researcher's e-mail account.

Data Analysis

For data analysis, the pre-participation cardiovascular screening procedures survey was divided into five sections (demographics, pre-participation exam, medical history, physical examination, and referral). The survey responses of head certified athletic trainers or directors of athletic training services from Division I, II, and III institutions was compared to the recommended AHA guidelines to evaluate the compliance of the screenings.

Statistical Analysis

Descriptive statistics included means and standard deviations. The responses to the questions for each NCAA Division I, II, and III institution was compared to the recommended AHA guidelines to evaluate the frequency. The Chi-Square analysis was used to compare the frequency of NCAA Division I, II, and III institutions in the

categories representing the recommended AHA guidelines. The P value was $p < 0.05$. All data was analyzed using SPSS Version 14.0 for Windows. (SPSS Inc. Chicago, IL.)

RESULTS

Demographic Information

A total of 327 head certified athletic trainers and director of athletic training services completed the survey responding to cardiovascular screening for a return rate of 33.5 percent. The numbers from each institution consists of 103 (31.5%) NCAA Division I, 91 (27.8%) NCAA Division II, and 133 (40.7%) NCAA Division III institutions. Of the 327 respondents, 203 (62.1%) were male and 80 (24.5%) were female. The majority surveyed were head athletic trainers 238 (82.4%) than to director of athletic training services 36 (12.5%). Of the respondents 229 (79.5%) received a masters degree and 278 (96.6%) were credentialed as ATC. The mean score of undergraduate student enrollment was 7562.70 ± 9146.915, student athletes 372.08 ± 173.942, and the number of varsity sports was 17.12 ± 14.263. Refer to Table D1 for additional information.

Question five refers to the importance of performing cardiovascular screening with pre-participation physical examinations. Of the responses 148 (47.1%) felt that performing a cardiovascular screening was very important with 64 (63.5%) from Division I, 35 (40.7%) from Division II, and 49 (38.9%) from Division III. Question six evaluated if participants are aware of the NCAA ten recommendations for cardiovascular screening. Of the responses a total of 172 (52.6%) were aware with 74 (71.8%) from Division I, 44 (48.4%) from Division II, and 54 (40.6%) from Division III. Question seven asked if participants are aware of the 2007 AHA recommendations for cardiovascular screening.

Of the total responses 124(37.9%) were aware, with 59 (57.3%) from Division I, 26 (28.6%) from Division II, and 39 (29.3%) from Division III.

Pre-Participation Physical Examination

A total of 322 (98.5%) of NCAA institutions perform a cardiovascular screening within their pre-participation physical examination referring to questions 8,14a-b, 15a, and 16 (Table D1). Of the responses a total of 113 (37.3%) obtained information from the NCAA to develop their cardiovascular screening. Institutions performed non-invasive testing at a minimum using 12-Lead ECG (n= 10, 3.3%), Echocardiogram (n= 8, 2.6%), and a Stress Test (n= 4, 1.3%). NCAA institutions that performed yearly pre-participation physical examinations were 186 (56.9%). One hundred eighty seven (27.2%) team physicians administered the tests, with 206 (63%) specializing in general medicine. Other professionals that assist in pre-participation physical examinations are certified athletic trainers (n= 257,78.6%), athletic training students (n= 135,41.3%), team physicians (n= 147,45%), and physical therapists (n= 34,10.4%). Refer to Table D3 for additional information.

American Heart Association Recommendations

Frequencies of NCAA institutions using the recommended American Heart Association guidelines referring to questions 13-15 are found in Table D4. Of the responses (n= 200,91.7%) required athletes to complete a medical history form. The medical history exam included exertional chest pain/discomfort (n= 270,82.6%), unexplained syncope/near syncope (n= 231,70.6%), excessive exertional and unexplained dyspnea (n= 236,72.2%), prior recognition of a heart murmur (n= 280,85.6%), and elevated systemic blood pressure (n= 226,69.1%). The physical exam included

percordial auscultations (n= 184,56.3%), femoral pulse (n= 47,14.4%), Marfan's stigmata (n= 97,29.7%), and brachial artery blood pressure (n= 197,60.2%).

Referral

The referral section includes questions 17-20 of the survey. The frequencies of responses are found in Table D5. Of the responses a total of 252 (77.1%) NCAA institutions have referred a student athlete based on a cardiovascular screening with 88 (85.4%) Division I, 72 (79.1%) Division II, and 92 (69.2%) Division III. Approximately ten or less athletes are referred each year from Division I (n= 83,80.6%), Division II (n= 70,76.9%), and Division III (n= 96,72.2%). The majority of athletes (n= 194,72.4%) that are referred to cardiologists. Of those athletes being referred the mean number of athletes being disqualified is .14 ± .793, athletes whose activities are modified with activity .40 ± 1.509, and athletes that can participate fully 3.94 ± 4.932.

NCAA Institutions Implementation of the American Heart Association Guidelines

Results from the 3 x 3 Chi-Square contingency table indicted that there was a significant difference (χ^2= 11.429, P= .022, CC= .184) between NCAA Division and the inclusion of the recommended AHA guidelines assessing from inadequate, moderate, and adequate (Table D6). A total of 327 (45%) NCAA institutions were found to be adequate including 9 of the 12 AHA recommendations for Division I (n= 103,55.3%) had the highest percentage followed by Division II (n= 91,48.4%), and Division III (n= 133,34.6%). NCAA institutions judged to be inadequate with 4 or less of the AHA recommendations were (n= 327,7%). Division I (n= 103,4.9%) had the lowest percentage, followed by Division II (n= 91,5.5%) and Division III (n= 133,9.8%).

DISCUSSION

In 1996 the American Heart Association consensus panel for pre-participation cardiovascular screening of athletes recommended twelve guidelines including family history and physical examination. Pfister et al.[23] in 2000 surveyed NCAA institutions to evaluate the compliance of using the recommendations of the AHA for cardiovascular screening of athletes. In 2007 this study was performed to note similarities and differences with the Pfister et al.[23] study on the 1996 AHA recommendations targeting the twelve recommended AHA guidelines. Therefore, this study was designed for the purpose of describing and comparing cardiovascular screening procedures with the recommended 1996 American Heart Association guidelines within NCAA Division I, II, and III institutions. The responses represent the practices of head certified athletic trainers at NCAA Division I, II, and III institutions. Based on the hypotheses in regards to the responses and the results of the Chi-Square all were accepted with implementation of the recommended 1996 American Heart Association guidelines.

According to these responses, a majority of NCAA Division I, II, and III institutions (98.5%) perform a cardiovascular screening within their pre-participation physical examinations. NCAA Division I institutions incorporate the majority (55.3%) of the recommended AHA guidelines within their cardiac screening compared with Pfister et al.[23] study. From previous studies performed in 2000; NCAA Division III institutions were found to have inadequate forms at 30 percent. In this study NCAA Division III institutions have improved finding only 9.8 percent to be using inadequate forms. The responses of NCAA Division I institutions included the majority (82.5%) of

recommended medical history questions and (48%) of recommended physical examination questions within their cardiac screening.

American Heart Association Recommendations

Pfister et al. 2000, [23] and Koester 2001, [20] conducted research using the recommended 1996 American Heart Association guidelines for cardiovascular screening of athletes. The recommended AHA guidelines for cardiovascular screening were divided into three categories: inadequate containing 0-4; moderate containing 5-8; and adequate containing 9-12. Each institution was evaluated to note the number of items incorporated into cardiovascular screening within the pre-participation physical examination. The previous studies also used the 1996 AHA consensus panel for pre-participation cardiovascular screening of athletes, which included family history and physical examination. The results of this study were similar to the previous studies with NCAA Division I implementing the majority of the recommendations from the AHA guidelines, a designated team physician was usually responsible for performing the evaluations, and inadequate forms were more frequent in NCAA Division II, and Division III schools and less common in Division I.

The second experimental hypothesis stated that based on the responses NCAA Division I institutions will incorporate the majority of the recommended American Heart Association guidelines within their cardiac screening. This was found to be of significance with a p value less than 0.05. NCAA Division I institutions (55.3%) incorporate nine or more of the recommended AHA guidelines. NCAA Division II and Division III institutions incorporate nine or more recommendations 48.4 percent and 34.6 percent, respectively.

The third experimental hypothesis stated that based on the responses NCAA Division III institutions will have improved on the implementation of the recommended American Heart Association guidelines within their cardiac screening from a previous study performed in 2000. This was found to be significant with a p value less than 0.05. NCAA Division I, II, and III institutions have significantly increased the number of recommended American Heart Association guidelines within their cardiovascular screening.

Pfister et al 2000, [23] contacted participants by phone to receive the most current version of the pre-participation physical examinations. From the PPE the cardiovascular portion was assessed in more detail comparing to the AHA recommendations. In addition 1110 NCAA institutions were surveyed by team physicians, athletic directors, and athletic trainers over a two year period from 1995 to 1997. In contrast to methods used in this current study, only head certified athletic trainers or directors of athletic training services were contacted at NCAA Division I, II, and III institutions via an electronic survey. The previous studies reported that only 26 percent of NCAA institutions were found to be using adequate forms. NCAA Division II and Division III were found to have inadequate forms 28 percent and 30 percent, respectively. Despite the differences according to the responses, of this survey 45 percent of NCAA institutions were found to be using adequate forms including nine or more of the recommended AHA guidelines within their cardiac screening. NCAA Division II and Division III were found to have a decrease in the use of inadequate forms 5.5 percent and 9.8 percent from 28 percent and 30 percent, respectively. Although the return rates of the surveys were not similar the current survey showed a significant improvement from 2000.

Pre-Participation Physical Examination

Pfister et al.[23] revealed that pre-participation physical examinations were required each year (51%). The current responses improved with NCAA institutions performing pre-participation physical examinations (56.9%) each year. Opinions vary as to how often student-athletes should be evaluated, with some advocating annual examinations, and others recommending one examination upon entrance with interim medical history updates.[12] The NCAA Committee on Competitive Safeguards and Medical Aspects of Sports has mandated a pre-participation evaluation for all collegiate athletes in Division I, II, and III before their first practice or competition upon entrance to the instituion. The NCAA also recommends that these evaluations be performed or supervised by a qualified physician on the basis of the cardiovascular recommendations. However, the AHA guidelines recommend that pre-participation physical examination with cardiac screening should be evaluated every second year of all the athletes, not just upon entrance. The majority of NCAA Division I pre-participation physical examinations were performed by team physicians (86.4%), followed by Division II (48.4%), and Division III with (40.6%). It might be concluded based on the results that some Division II and Division III institutions pre-participation physical examinations are being administered by non-university professionals such as family practitioners and sports medicine clinics.

Team physicians were used more often than other selections (57.2%) as the primary administrator of the PPE. Non-team physicians were used more in Division II and Division III institutions 27.5 percent and 47.4 percent, respectively. Of the team physicians involved most specialized in general practices (63%) and orthopedics (44.3%). This is consistent with the study performed by Pfister et al.[23] that these physicians that are

primarily orthopedists may not be familiar with cardiovascular evaluations since their primary focus may be only musculoskeletal. In addition, the head certified athletic trainer may not have contacted the physician for the verification of the screening that the physicians are following. In some cases, a screening is performed even though it is not recorded on a checklist, as may be evident in Marfan's stigmata.

Cardiovascular Screening

The medical history and physical examination protocol was developed by head certified athletic trainers with information from a variety of sources such as the AHA, NCAA, and AMA. Three hundred and twenty-two of the 327 responses indicate that they require a cardiovascular screening within their pre-participation physical examination. The majority (91.7%) of the respondents indicated that their institution requires the completion of a medical history form yearly by student-athletes. This study indicated a high number of recommended AHA conditions included in the medical history examination.

Prior recognition of heart murmur was included most often (85.6%) and elevated systemic blood pressure was included the least (69.1%). It has been reported that the standard personal history conveys a generally low specificity for detection of many cardiovascular abnormalities that lead to sudden death in young athletes, that is why it is particularly important to inquire about symptoms such as arrhythmias and excessive fatigability that may indicate a cardiovascular problem. The medical history form is the most efficient and least expensive tool to identify a potential problem, and institutions are increasing the implementation within their pre-participation physical examination. Excessive exertional and unexplained dyspnea (72.2%) were shown to be included but

may be less likely to be used due to the omission of the NCAA recommendation. It is interesting to note that more institutions are aware of the NCAA recommendations for cardiovascular screening (52.6%) rather than the AHA recommendations (37.9%).

The most frequently preformed cardiovascular examination procedure within a pre-participation physical examination was brachial artery blood pressure measurement (60.2%). The second most common was precordial auscultations (56.3%). The least likely to be performed were Marfan's stigmata and femoral pulse measurements 29.7 percent and 14.4 percent, respectively. The NCAA omits the observation of Marfan's stigmata indicting the low prevalence among pre-participation physical examinations. Pfister et al.[23] found an even lower number in the use with only 2 percent of the respondents including examination of Marfan's stigmata and femoral pulse. It is also important to note that none of these aforementioned procedures are mandatory only recommendations, resulting in a decrease of physical examination compared to medical history examination procedures performed. This may be a result of general practitioners, orthopedists, and certified athletic trainers administering the cardiovascular screening as opposed to cardiologists performing this section of the evaluation. In addition these professionals may not be as aware of cardiovascular conditions among collegiate athletes including physical signs for Marfan's stigmata.

Non-invasive testing was utilized in the least 3.3 percent of institutions performing a 12-Lead ECG. This is consistent with research findings and recommendations indicating that although non-invasive testing such as 12-Lead ECG or echocardiogram can enhance the diagnostic power of the standard history and physical examination, it is not practical, prudent, or cost-effective to recommend routine use.[12,23]

Referral

The average number of athletes referred for further cardiovascular examination based on their cardiovascular screening within their pre-participation physical examination was 77.1 percent. Division I (85.4%) referred the majority of athletes followed by Division II (79.1%), and Division III (69.2%). This may be a result of the majority of Division II and Division III institutions performing pre-participation physical examinations by non-university professionals or do not have access to cardiologists.

The averages of athletes that are disqualified from participation in this study are less than 0.14 per year. The estimated numbers from previous studies that disqualify athletes from participation are less than 0.5 per year. Approximately 3.94 athletes per year were cleared to play with no restrictions. The athletes were most commonly referred to cardiologists (72.4%) with Division I performing the most followed by Division II and Division III. Participation eligibility for athletes diagnosed with cardiovascular abnormalities is judged using guidelines from the 36th Bethesda Conference consensus panel.[8,20,21] Nevertheless, when performed optimally, pre-participation physical examination with customary history and physical examination has the potential to identify cardiovascular abnormalities such as hypertrophic cardiomyoptahty, Marfan syndrome, some cases of arrhythmogenic right ventricular dysplasia, dilated cardiomyopathy, and atherosclerotic coronary artery disease.[23] Marfan syndrome and systemic hypertension are identifiable from physical examination, as are diseases with a systolic heart murmur. [23]

CONCLUSION

Results from this study reported that NCAA institutions have increased the number of recommendations of the 1996 American Heart Association guidelines used for cardiovascular screening of collegiate athletes. When the recommended AHA guidelines were used for comparison, only 7 percent of the NCAA institutions were considered to have inadequate screening forms. This is encouraging, indicating that these NCAA institutions recognize the importance of cardiovascular screenings within pre-participation physical examinations.

Pre-participation physical examinations with customary history and physical examination has the potential to identify cardiovascular abnormalities such as hypertrophic cardiomyopathy, Marfan's syndrome, some cases of arrhythmogenic right ventricular dysplasia, and coronary artery disease. Despite the overall low incidence of sudden cardiac death within the population it is important to focus the pre-participation physical examination on safety and prevention of the athletic injury and predisposition of conditions or diseases. The main goal of pre-participation physical examination for athletes is to detect previously unrecognized cardiovascular diseases that may be associated with an increased risk of sudden cardiac death. The continual improvement of screening with implementation of the recommended AHA guidelines and recognition of cardiovascular conditions by the certified athletic trainers and sports medicine professionals has the potential to reduce the rate of sudden cardiac death among collegiate athletes.

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APPENDICES

APPENDIX A

THE PROBLEM

Research Question

Sudden cardiac death is defined as a nontraumatic, nonviolent, unexpected event resulting from sudden cardiac arrest within six hours of a previously witnessed state of normal health. [2,24] The occurrence of unexpected sudden cardiac death in student-athletes is an uncommon but often highly visible event that has heightened public concern and that of the medical community. [23] In recent years, there has been considerable interest regarding the role of pre-participation screening for early identification of those cardiovascular diseases which are responsible for athletic field deaths and for disqualification of athletes at risk. [10] With the implementation of the recommended American Heart Association guidelines into NCAA Division I, II, and III student-athlete's pre-participation physical examination could reduce the risk of sudden cardiac death.

The 2007 updated American Heart Association twelve recommendations for preparticipation cardiovascular screening of athletes include the following twelve questions. The medical history portion includes questions 1-8: 1) personal history of exertional chest pain or discomfort; 2) unexplained syncope or near-syncope; 3) excessive exertional and unexplained dyspnea or fatigue associated with exercise; 4) prior recognition of a heart murmur; 5) elevated systemic blood pressure; 6) family history of premature death before age 50 years due to heart disease; 7) disability from heart disease in a close relative of 50 years or less; and 8) specific knowledge of certain cardiac conditions in family members: hypertrophic or dilated cardiomyopathy, long QT

syndrome or other ion channelopathies, Marfan syndrome, or clinically important arrhythmias. Physical examination recommendations include 9-12: 9) physical examination for heart murmur- auscultations performed both supine, and standing; 10) femoral pulses; 11) physical stigmata of Marfan syndrome; and 12) brachial artery blood pressure in the sitting position.[11,21,23]

The university's medical staff consisting of team physicians, orthopaedics, and certified athletic trainers need to focus on the pro-active approach to ensure the safety of each student-athlete. The role of the medical staff in this setting is primarily to attempt resuscitation and stabilization of the athlete. However, it is helpful for the medical staff to be aware of the demographics, risk factors, etiologies, and current preventive strategies regarding sudden cardiac death.[12] In this regard, the status of pre-participation cardiovascular screening available to student-athletes in colleges is unresolved, as now is the time to evaluate the strengths and limitations of this process.[23]

In 2000 Pfister et al.[23] compared collegiate athletes' pre-participation cardiovascular screening with the 1996 American Heart Association guidelines. Pfister et al.[23] developed twelve recommendations from the AHA guidelines they felt should be included in cardiovascular screenings on the collegiate level. When compared to the 1110 NCAA colleges and universities only 26 percent of NCAA schools were found to be using "adequate" history and physical examination forms containing at least 9 of 12 recommended items. NCAA Division II and III schools 28 percent and 30 percent, respectively were found to have inadequate forms containing 4 or fewer of the 12 recommended items more often than Division I schools at 14 percent. Koester[20]

performed a follow up study in 2001 and noted the results had not changed from the previous study.[20]

In a previous research study conducted by the researcher in 2006 at Heidelberg College using NCAA Division III universities in the Ohio Athletic Conference, responses indicated that the pre-participation physical examination with a cardiac screening were inadequate. There was a correlation between the financial status of the university and quality of pre-participation physical examination with cardiac screening. All universities required a pre-participation physical examination but only half performed the physical examination with the university's medical staff. In the profession of athletic training it is vital to ensure the best, utmost quality of care to the student-athletes by being knowledgeable on the cardiac conditions and the 2007 updated twelve recommendations of the American Heart Association.

To assess screening practices for cardiovascular diseases in NCAA Division I, II, and III athletes the following research questions can be asked: 1) Do NCAA Division I, II, and III have a cardiac screening within their pre-participation physical examination?; 2) Do NCAA Division I, II, and III implement the recommended American Heart Association guidelines within their cardiac screening of their pre-participation physical examination?; 3) Has the NCAA Division I, II, and III improved their cardiac screening with implementation of the recommended American Heart Association guidelines compared to 2000?

Experimental Hypotheses

1. Based on the responses the majority of NCAA Division I, II, and III institutions will perform a cardiac screening within their pre-participation physical examination.

2. Based on the responses NCAA Division I institutions will incorporate the majority of the recommended American Heart Association guidelines within their cardiac screening.

3. Based on the responses NCAA Division III institutions will have improved the most on implementation of the recommended American Heart Association guidelines within their cardiac screening from previous study performed in 2000.

4. Based on the responses NCAA Division I institutions will include the majority of all the recommended medical history questions within their cardiac screening.

5. Based on the responses NCAA Division I institutions will include the majority of recommended physical examination questions within their cardiac screening.

Assumptions

1. The participants in this study responded honestly to the questions in the survey.

2. The participants in this study responded to the questions to the best of their ability.

3. The survey was valid and reliable.

4. The survey accurately related to the importance of the recommended American Heart Association guidelines in a cardiac screening.

Delimitations

1. This study was conducted from a population of NCAA Division I, II, and III certified athletic trainers and cannot be generalized to the general population as a whole.

2. The cardiac screening pertained to NCAA Division I, II, and III athletes ages 18-25.

3. Only a selected group of head certified athletic trainers at Division I, II, and III institutions participated in the survey in evaluating their institution's cardiac screening

Operational Definitions

1. American Heart Association (AHA) - Recommendations to include in cardiac screening to recognize and prevent cardiovascular diseases in athletes.

2. Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC) - Is a disorder in which normal myocardium is replaced by fibrofatty tissue. [25,26]

3. Athlete- Implies involvement in a regimented exercise program with participation in a team or individual sport. [12,13]

4. Bethesda Conference 36- Offer widely accepted eligibility and disqualification recommendations for competitive athletes with established cardiovascular abnormalities. [5]

5. Brugada Syndrome- Caused by unpredictable episodes of recurrent ventricular tachycardia. [5,27]

6. Certified Athletic Trainer (ATC) - Responsible for athletic injury prevention and risk management; recognition, evaluation, and assessment of injuries; immediate care of injury and illness; rehabilitation and reconditioning of athletic injuries; health care organization and administration; and professional development and responsibility.

7. Channelopathies (ion)- Ion channels responsible for three of the fundamental ionic currents in the cardiac action potential.[28]

8. Commotio Cordis- An electrophysiological event caused by precordial chest impact that occurs in individuals free from structural cardiac disease. [5,12]

9. Congenital Coronary Artery Anomalies- Presumably leads to myocardial hypoperfusion during exercise. [5,12]

10. Dyspnea- Difficulty breathing that results from inadequate cardiac output.[7,26,29]

11. Echocardiogram- The graphic record produced by echocardiography.[7,30]

12. Echocardiography- A noninvasive diagnostic method that uses ultrasound to visualize cardiac structures. [7,30]

13. Electrocardiogram (ECG) - A record of the electrical activity of the heart, consisting of waves.[31]

14. Exertional Chest Pain- Pain in the chest with an increase in activity. [7,30,31]

15. Heart Murmur- An abnormal sound heard on auscultation of the heart and adjacent large blood vessels. [1,12]

16. Hypertrophic Cardiomyopathy (HCM) - The abnormal thickening of the heart muscle. [1,6,30]

17. Long QT-Syndrome- An abnormality of the electrical conduction system characterized by prolonged repolarization of the ventricle. [4,25]

18. Marfan Syndrome- An autosomal dominant genetic disorder of connective tissue characterized by disproportionately long limbs, long thin fingers, a relatively tall stature, and a predisposition to cardiovascular abnormalities, specifically those affecting the heart valves and aorta. [4,25,32]

19. Mitral Valve Prolapse (MVP) - Physical examination may reveal a midsystolic click and a late systolic murmur. [4,25,32]

20. Myocarditis- Inflammatory condition of the myocardium. [11,12,33]

21. Pre-Participation Physical Examinations for Cardiovascular Disease- Consists of standard history and physical examination. [7,8,23]

22. Sudden Cardiac Death (SCD) - Nontraumatic, nonviolent, unexpected event resulting from sudden cardiac arrest within six hours of a previously witnessed state of normal health. [1,18,24]

23. Syncope- Transient loss of consciousness, accompanied by an inability to maintain an upright posture. [1,18,24]

24. Systemic Blood Pressure- Blood pressure during contraction of the ventricles that is normally 90 to 135 mmHg. [1,18,24]

25. Wolff- Parkinson- White Syndrome (WPW) - An abnormality of the cardiac conduction system whereby an additional electrical pathway can lead to tachycardia. [12,34]

Limitations

1. Participants may not fill out the survey completely.

2. Participants from NCAA Division I, II, and III institutions may respond by what they feel the investigator would like to hear.

3. The survey assumes the participants know the recommended American Heart Association guidelines.

4. History- an internal validity threat based on the possibility of external events affecting the response of participants.

5. Selection of participants- an external validity threat based on the choice of participants as a random group or an experimentally accessible group.

6. Generalizations of findings to other settings- an external validity threat where the findings of the participants are generalized towards a target population.

Significance of the Study

The current recommendations from the NCAA on pre-participation physical examinations are to mandate that prior to participation in any physical activity all prospects, walk-ons, and student-athletes shall be required to undergo a medical examination that is administered or supervised by a physician. The rationale is that the committee on Competitive Safeguards and Medical Aspects of Sports believes before student-athletes accept the rigors of organized sport, their health should be evaluated by qualified medical personnel.[21] The intent is to ensure all participants have a medical examination upon entrance to the sport. During subsequent years, an interim history should be performed upon which a physician would determine if additional physical, cardiovascular or neurological examinations are required.[21]

The NCAA recommends ten of the twelve recommended history and physical examination items promoted by the AHA, omitting only a history of fatigability and Marfan stigmata on examination.[21] These ten recommendations were developed from the 3rd edition of the Pre-Participation Physical Examination Monograph from a combination of six medical societies.[21] The NCAA recommends the use of the ten as a reference in developing a cardiovascular examination. These minimal standards are lacking the recommended twelve American Heart Association guidelines for cardiovascular screening in the competitive athlete.[21]

The primary and secondary objectives of a pre-participation physical examination with a cardiac screening are: 1) Detect medical or musculoskeletal conditions that may predispose an athlete to illness or injury during the competition; 2) Detect potentially life-threatening or disabling medical or musculoskeletal conditions that may limit an athlete's

safe participation; and 3) Address legal or insurance concerns. The secondary objectives are to: 1) Determine the general health of the athlete; 2) Counsel the athlete; and 3) Assess fitness level for specific sports. [20] In athletes, the main goal of pre-participation screening is to detect previously unrecognized cardiovascular disease that may be associated with an increase risk of sudden cardiac death.[35]

The significance of the study is to increase awareness of the recommended American Heart Association guidelines for cardiovascular screening to the medical staff of the NCAA institutions. The medical staff should be made aware of where to obtain these recommended guidelines via the American Heart Association. Certified athletic trainers must complete continuing educational units to maintain present status within a period of time, a course of cardiovascular conditions related to sudden cardiac death could be offered on the current status and conditions to credit towards the needed CEU's. A symposium could also be offered at the national convention for athletic training offering updated screening tools used for cardiovascular evaluation.

The implementation of the recommended American Heart Association guidelines into the cardiac screening creates a universal protocol for the medical staff of the NCAA Division I, II, and III institutions to screen and restrict athletes from participation. It is essential to advance awareness and the necessity of an annual cardiac screening for each NCAA collegiate student-athlete. Increasing the knowledge of cardiac conditions and causes of sudden cardiac death, certified athletic trainers can be better prepared on and off the field. Certified athletic trainers play an important role in implementing the 2007 AHA guidelines as they are usually the first line of defense with student-athletes and their health. This study was used to update the results of previous studies on cardiovascular

screening by surveying head certified athletic trainers or director of athletic training services at NCAA Division I, II, and III institutions.

APPENDIX B

LITERATURE REVIEW

Introduction

In past several years there has been increasing interest and concern in the medical and lay communities about sudden and unexpected catastrophies in young trained athletes. The risks associated with participation in organized competitive sports are diverse, ranging from sudden collapse due to various underlying cardiovascular disease to death from nonpenetrating chest impact.[1-7] Interest in athletic field deaths has also accelerated because of the recognition that these catastrophic events are probably more common than previously thought, may occur in athletes of both genders and all races, and that the responsible structural cardiovascular diseases may be clinically identifiable.[1,2,9]

Sudden cardiac death in young athletes is rare. The exact prevalence is not known as a national database to track the death of athletes is nonexistant.[4,5,10-14] The largest available studies estimate the incidence among high school and collegiate athletes to be between 1 per 100,000 and 1 per 300,000, respectively, each year.[4,5,10-14] An estimated number of 50 to 100 cases occur annually in the United States.[4,5,10-14] Despite the overall low incidence of sudden cardiac death within the general population, it represents 30 percent of all nontraumatic deaths, with one third of victims younger than 65 years.[4,5,10-14] Eighty percent of sudden cardiac death cases in young athletes occur either during or immediately after strenuous exercise.[4,5,10-14] This suggests that physical activity may be a trigger for cardiac arrhythmias in those with certain cardiac disease. Sudden cardiac death is an umbrella of diseases consisting of the most common and the least common diseases. The most common diseases in young athletes in the United

States are hypertrophic cardiomyopathy accounting for at least 36 percent of deaths and congenital coronary artery anomalies at 19 percent.[6,13,15] The less common diseases: arrhythmogenic right ventricular dysplasia, myocarditis, Marfan syndrome, long QT-syndrome, mitral valve prolapse, commotio cordis, Wolff-Parkinson-White syndrome, and Brugada syndrome.[4,5,10-14] The early identification of cardiac disease in athletes is, therefore, of the utmost importance, especially because the majority of sudden death cases could be diagnosed antemortem with appropriate screening tests.[10-14,21]

The 2007, American Heart Association recommendations include twelve guidelines for the most practical and effective screening procedures and strategies.[20,21] If cardiac disease is identified through screening and referral results in a definitive cardiac diagnosis, recommendations regarding further competitive and recreational activity should be formulated in accordance with the consensus panel guidelines of the 36th Bethesda Conference.[10-12,20,21] It is essential to advance awareness and the necessity of an annual cardiac screening for each NCAA collegiate student-athlete. In the previous studies using the 1996 AHA guidelines, Pfister et al.[23] selected twelve items that should be incorporated for cardiac screening at the collegiate level. From that study NCAA Division I, II, and III institutions used cardiovascular screening procedures that were "adequate" to "inadequate," respectively. By increasing the knowledge of cardiac conditions and causes of sudden cardiac death, certified athletic trainers can be more prepared on and off the field. The review of literature will further address the following topics: epidemiology; causes of sudden cardiac death in athletes; less common causes of sudden cardiac death in athletes; pre-participation physical examination; American Heart

Association recommendations for pre-participation cardiovascular screening; and NCAA compliance with American Heart Association guidelines.

Epidemiology

Cardiovascular disease represents the leading cause of death in the United States.[4,5,10-13,35,36] Sudden cardiac death is defined as a nontraumatic, nonviolent, unexpected death due to cardiac causes within one hour of the onset of symptoms, or within six hours of witnessed normal state of health. Sports-related deaths are defined as those with symptoms occurring within one hour of sports participation.[10,13,37,38]

Sudden death of healthy athletes is an unexpected and always distressing event, and through extremely rare, can have a tragic and devastating impact on the family, community, and medical staff involved. [10,12,21,37,39,40] Conditioned athletes are regarded to as the healthiest segment of society while exercise itself is considered a means of improving personal health and decreasing the chance of cardiovascular disease. [12] The first proposed case of sudden cardiac death in an athlete involved Pheidippides in 490 BC. [12,37,41] More recent accounts of athletes dying suddenly include: Loyola Marymount basketball player Hank Gathers (1990), marathon runner Jim Fixx (1984), US Olympic volleyball player Flo Hyman (1986), former professional basketball players Pete Maravich (1980) and Reggie Lewis (1993), and Olympic figure skater Sergei Grinkov (1995). All these professional athletes suffered from presumed sudden cardiac death.[10,12,35]

Sudden cardiac death in young athletes is rare. The exact prevalence is not known as there is no national database to track the death of athletes. Lack of a national registry for sudden cardiac death in athletes might lead to an underestimation of

deaths.[10,12,42] The largest available studies estimate the incidence among high school and collegiate athletes to be between 1 per 100,000 and 1 per 300,000, respectively, each year.[10,12,42] An estimated number of 50 to 100 cases occur in young athletes annually in the United States. Despite the overall low incidence of sudden cardiac death, it represents thirty percent of all nontraumatic deaths. The incidence of cardiovascular collapse as the cause of athletic fatalities in high school and college athletes outnumbers death caused by trauma by nearly 2 to 1.[10,12,42]

Eighty percent of cases of sudden cardiac death in athletes occur either during or immediately after strenuous exercise.[42,43] This suggests that physical activity may be a trigger for cardiac arrhythmias and other inherited or congenital structural and functional cardiovascular abnormalities.[42] Athletes suffering from sudden cardiac death participate in a variety of sports, most frequently basketball and football. Most cases of sudden cardiac death occur in men with a ratio ranging from 5:1 to a ratio of 9:1 for females.[10,12,42]

The major mechanisms involved in sudden cardiac death are related to haemodynamic and electrophysiological changes brought about by exercise in the susceptible individual.[35,37,44,45] Changes in myocardial structure, function, and blood flow can affect the cardiac response to exercise.[35,37,44,45] Haemodynamic fluctuations in the normal myocardium that occur with exercise vary with the type of exercise performed.[35,37,44,45] Exercise also affects the electrical function of the heart as changes in sympathetic stimulation occur. Sports are categorized with regard to type and intensity, the mechanical action involved and the metabolism requirements inherent in each sport determine further classification as dynamic or static, and aerobic or anaerobic.[35,37,44,45]

These factors exaggerate cardiac responses such as blood pressure, heart rate, and myocardial contractility, which lead to increased myocardial oxygen demands and cardiac arrhythmias.[35,37,44,45] Therefore, sudden cardiac death in athletes is caused by the combination of exercise and underlying heart disease rather than by exercise alone, which usually leads to the final common pathway of lethal arrhythmia.[35,37,44,45]

Causes of Sudden Cardiac Death in Athletes

Sudden cardiac death is caused by the combination of exercise and underlying heart disease rather than by exercise alone, which usually leads to the final common pathway of lethal arrhythmia.[35,37,44,45] By far, the most common reason for young athletes to suffer from sudden cardiac death in the United States is hypertrophic cardiomyopathy, accounting for at least 36 to 40 percent of deaths.[12] The second most frequent cause of death, encountered in young athletes 17 to 19 percent of deaths, is congenital coronary anomalies.[12] Table B1 categorizes the diseases associated with sudden cardiac death among young athletes.

Table B1. Causes of Sudden Cardiac Death in Young Athletes[61]

Most Common	Less Common	Rare
HCM	Myocarditis	WPW
CCAA	ARVD	Long QT Syndrome
	Marfan's Syndrome	MVP
		Commotio Cordis
		Brugada Syndrome

Key: HCM=Hypertrophic Cardiomyopathy; CCAA=Congenital Coronary Artery Anomalies; ARVD=Arrhythmogenic Right Ventricular Dysplasia; WPW=Wolff-Parkinson-White; MVP=Mitral Valve Prolapse

Hypertrophic cardiomyopathy: The most common diseases for sudden cardiac death in the United States is hypertrophic cardiomyopathy, accounting for at least 36 percent of deaths in athletes.[1,2,12] Firoozi et al.[42] reports that hypertrophic cardiomyopathy accounts for 40 to 50 percent of sudden cardiac death in young athletes.

Hypertrophic cardiomyopathy is a complex and relatively common genetic cardiac disease. [1,2,31,42] The disease is characterized by myocardial hypertrophy, abnormal diastolic filling, and in about one third of cases, intermittent left ventricular outflow obstruction. [1,2,31,42] Myocardial hypertrophy, which involves left and/or right ventricle, is usually asymmetric, and sometimes includes interventricular septum as well. [6] Impaired diastolic filling, due to the massively hypertrophied left ventricle causes reduced chamber size and poor compliance with reduced stroke volume.[6] The abnormal thickening of the heart stiffens the walls so that it is less able to efficiently pump blood through out the body.[30]

Hypertrophic cardiomyopathy is genetically transmitted as an autosomal dominant condition with variable expression because it may not manifest itself until adolescence or young adulthood.[6,31] It may be difficult to distinguish mild hypertrophic cardiomyopathy from the normal cardiac hypertrophy that occurs in highly trained athletes. [1,2,31,42]

This disease occurs in approximately 1 in 500 athletes, and displays clinical heterogeneity ranging from no symptoms, to arrhythmias, heart failure and premature sudden death. [29,46,47] In a series of sudden cardiac death occurring during exercise in patients with hypertrophic cardiomyopathy, only 35.7 percent had a previous cardiac evaluation for risk factors that included syncope, family history, murmurs, fatigue, or ventricular tachycardia on exercise testing. [5,47,48] Twenty-one percent of athletes who died from hypertrophic cardiomyopathy had symptoms of cardiovascular disease before their death. Symptoms may include chest pain, exertional dyspnea, lightheadedness, or syncope. [29,46,47]

Hypertrophic cardiomyopathy should be suspected in any athlete in whom a harsh systolic ejection murmur is heard on examination.[48-50] The characteristic murmur increases in intensity with maneuvers that decrease venous return such as Valsalva's maneuver.[48-50] Examination may also reveal the presence of a fourth heart sound or a rapid initial upstroke of the carotid pulse. These athletes will also demonstrate signs of left ventricular enlargement electrocardiographically and radiographically.[48-50]

Until recently, no therapeutic intervention had been identified to prevent sudden death in hypertrophic cardiomyopathy. A case report by Jayatilleke et al.[46] highlights the role of the implantable cardioverter defibrillator (ICD) in preventing sudden death in patients with hypertrophic cardiomyopathy. ICD implantations are appropriately selected for individuals with hypertrophic cardiomyopathy that are at high risk of sudden cardiac death. The difficulty in using this treatment is identifying those individuals with hypertrophic cardiomyopathy that are at the highest risk for sudden cardiac death. Specifically, a family history of hypertrophic cardiomyopathy related sudden death, previous cardiac arrest or sustained ventricular tachycardias, and massive left ventricular hypertrophy appear to be the strongest predictors of sudden death and should identify patients who would most benefit from an ICD. Appropriate device intervention occurred at 11 percent annually for secondary prevention following cardiac arrest and 5 percent annually for primary prevention based on risk factors. This case study followed by Maron et al.[1,2] highlights the life saving value of the ICD but potential risk factors of identification need to be considered. Understanding the genetic basis and molecular mechanisms that cause sudden death may identify potential new therapeutic targets for both pharmacological and gene based interventions. Treatment strategies for

hypertrophic cardiomyopathy should be dependent on the clinical symptoms and stratifications of sudden death risk. [48-50]

Congenital coronary artery anomalies: Unlike sudden cardiac death in adults and the elderly, sudden cardiac death in young people is often triggered by nonatherosclerotic coronary artery disease, either acquired or congenital in origin. In particular, congenital coronary artery malformations were reported as the cause of 12 to 35 percent of sudden death in the young and a wide range of abnormalities.[51] Second in frequency to hypertrophic cardiomyopathy in the United States as a cause of young sudden cardiac death, congenital coronary artery anomalies are often asymptomatic. [1,48,52] The most common coronary anomaly associated with sudden cardiac death in athletes is a left main artery arising from the right sinus of Valsalva. [1,48,52] Other particularly life-threatening coronary artery anomalies include left coronary artery from the pulmonary artery and single coronary arteries. In fact, after a record-breaking, Hall of Fame career in basketball, "Pistol Pete" Maravich died at age 40 during a pick up basketball game, and was later found to have a single coronary artery.[1,48,52] Coronary anomalies presumably lead to myocardial hypoperfusion during exercise. [1,48,52] Possible reasons for ischemia in anomalous coronary artery are outward expansion of the roots, compression of the ostial lumen, pulmonary trunk dilation during exertion, and increase in myocardial oxygen.[1,48,52]

Some individuals with coronary artery anomalies may demonstrate symptoms such as syncope or angina before an event. Imaging modalities, including echocardiography, angiography, computed tomography, and magnetic resonance imaging

have all been used to visualize coronary artery anomalies. Among athletes who died of this disorder, 31 percent were found to have symptoms before death. [1,48,52,53]

Athletes with congenital coronary anomalies should refrain from competitive sports and strenuous physical activity because of the increased risk of sudden cardiac death. [1,48,52,53] Furthermore, a prompt evaluation by a cardiothoracic surgeon should be performed for consideration of coronary artery re-implantation or coronary artery bypass grafting to reduce the risk of sudden cardiac death.[1,48,52,53] Diagnosis of this condition is crucial, not only because it is life-threatening but because it can be surgically corrected.[1,48,52,53] The 36th Bethesda guidelines recommend a three month recovery period after postoperative repair, followed by a maximal exercise stress test before resumption of competition. [1,48,52,53]

Less Common Causes of Sudden Cardiac Death in Athletes

Infrequent causes of sudden cardiac death representing 9 to 10 percent of deaths are right ventricular dysplasia, myocarditis, Marfan's syndrome, long QT syndrome, mitral valve prolapse, commotio cordis, Wolff- Parkinson- White syndrome, and Brugada syndrome.

Arrhythmogenic right ventricular dysplasia: Arrhythmogenic right ventricular dysplasia has been shown to have an incidence of six per 10,000 persons. [26,54-56] Arrhythmogenic right ventricular dysplasia accounts for three to four percent of deaths in sports.[26,54-56]

Arrhythmogenic right ventricular dysplasia is a disorder of the heart muscle characterized by ventricular arrhythmias and structural abnormalities of the right ventricle due to progressive replacement of the myocardium with fibrofatty tissue. [26,54-56]

The most common location for this tissue transformation is between the anterior infundibulum, right ventricular apex, and inferior or diaphragmatic aspect of the right ventricle. [26,54-56] This process results in the thinning and dilatation of the right ventricular wall and leads to recurrent and intractable ventricular tachyarrthmias. [26,54-56]

Athletes with arrhythmogenic right ventricular dysplasia are frequently asymptomatic, but may present with palpitations, syncope, or sudden cardiac death. Assessing the size and function of the right ventricle and wall is much more complex than in the left ventricle.[56] Studies performed by Henriksen et al.[57] and Makan et al.[56] defined elite endurance athletes as a higher risk for arrhythmogenic right ventricular dysplasia. The mechanism leading to structural damage is the long lasting volume overload on the right ventricle. In both studies echocardiographies were used to measure the right and left ventricular chambers. In the right ventricle the inflow and outflow tracts are oriented at different axes, creating a complex right ventricular geometry with no easily identifiable landmarks, making reproducible imaging planes difficult. Diagnosis of this disease often proves to be difficult but appears to have a strong familial association.[26,54-58] The diagnosis is based on a scoring system proposed by McKenna[26,54-58].

Arrhythmogenic right ventricular dysplasia is the most common cause of sudden cardiac death among young athletes in Italy. Arrhythmogenic right ventricular dysplasia accounts for 22.4 percent of sudden cardiac deaths among young athletes. This indicates the importance of both left and right ventricular segmental analysis and measurements by using multiple cross sections when examining athletes with cardiac symptoms.[26,54-58]

For most cases of arrhythmogenic right ventricular dysplasia, treatment involves antiarrhythmic drug therapy or placement of an ICD. [26,54-58] Because rigorous exercise may induce ventricular tachycardia and exacerbate the disease, athletes with arrhythmogenic right ventricular dysplasia should be limited to participation in low-intensity sports. [26,54-58]

Myocarditis: Myocarditis is s a continuum of three distinct disease processes, one evolving into the other with transitional periods of indistinctness.[21,59-61] This inflammatory condition of the myocardium is frequently the result of a viral infection most commonly caused by either coxsackievirus or echovirus. [21,59-61] This infection then can progress to an autoimmune phase after resolution or reduction of the initial infection, and then finally to progressive dilatation after resolution or reduction of the autoimmune injury. [21,59-61]

Characteristic symptoms of myocarditis include a prodromal viral illness followed by progressive exercise intolerance and congestive symptoms of dyspnea, cough, and orthopnea. [21,59-61] On physical examination, an audible S_3 gallop or soft apical murmur as well as signs of congestive heart failure may be present. [21,59-61] Myocarditis can also be examined by the longitudinal peak strain using the Tissue Doppler Imaging.[62]

Treatment at the viral stage is eradiction of virus and amelioration of viral injury.[21,59-61] The autoimmune phase immune suppression is the most appropriate treatment, unless significant viral replication persists. [21,59-61] Treatment for autoimmune injury is reversal by remodeling and promotion of myocyte survival, attenuation of continued neurohormone, cytokine activation, and reduction of hemodynamic stress.[21,59-61] Sudden cardiac death may occur in the presence of either active or healed myocarditis.

Thus, a convalescent period of at least six months is recommended before a return to competitive sports. [21,59-61]

Mitral valve prolapse: Mitral valve prolapse (MVP) is the most common valvular disorder, occurring in approximately five percent of the population.[63-67] Mitral valve prolapse is a congenital condition in which the mitral leaflets protrude into the left atrium during systole. [63-67] It is most commonly caused by myxomatous proliferation of the leaflets. [63-67]

Most patients who have MVP remain asymptomatic. [63-67] Other patients can have chest pain, supraventricular arrhythmias, or transient ischemic attacks. [63-67] Some patients can go on to develop progressive, sever mitral regurgitation. Severe mitral regurgitation can lead to congestive heart failure and a predisposition for sudden death. This is the likely mechanism for sudden cardiac death in young athletes. It is an uncommon cause, accounting for two percent of cases. [63-67]

Physical examination of patients with mitral valve prolapse may reveal a midsystolic click and a late systolic murmur. [63-67] If an athlete with known mitral valve prolapse develops syncope, exertional chest pain, or moderate-to-severe mitral regurgitation, it is recommended that athlete participation be restricted. [63-67] The 36th Bethesda guidelines allow athletes who have MVP to participate in all sports as long as they are asymptomatic, have no family history of sudden death, no left ventricular dysfunction, no arrhythmias, and no severe mitral regurgitation. [63-67]

Marfan's syndrome: The prevalence of Marfan's syndrome in the United States population is 1 per 10,000.[28,32,68] Marfan's syndrome, an autosomal dominant disorder of the fibrillin gene, accounts for the majority of cases of aortic rupture or dissection seen in

young athletes.[28,32,68] Flo Hyman, the famous Olympic volleyball player, died at the age of 31 from this disorder.[28,32,68] Because of alterations in connective tissue of the aorta, root dilation with subsequent aortic regurgitation or dissection may be seen. These changes, along with aortic rupture, account for most deaths in this disorder.[28,32,68]

Diagnosis of Marfan's syndrome is based on clinical features and a detailed family history.[28,32,68] Skeletal changes in Marfan's syndrome are easiest to recognize and classically include long thin fingers, long limbs, tall stature, a funnel chest with a pigeon breast, rib deformities from bone overgrowth, a high arched narrow palate, and an excessive arm span.[28,32,68] Ophthalmologic examination may show myopia and ocular lens subluxation, and echocardiography may reveal a dilated aortic root or MVP.[28,32,68] A detailed family history will often reveal an unusual body habitus and may disclose associated cardiovascular events.[28,32,68] The primary goal of management is to detect cardiovascular manifestations early, with the intent of intervening before more significant complications arise. Surgical therapy is the mainstay of treatment for patients with these adverse cardiovascular complications.[28,32,68]

The 36th Bethesda guidelines recommend that athletes who have Marfan's never participate in high intensity sports or sports that involve bodily contact. Athletes who have no aortic root dilation or mitral regurgitation and no family history of sudden cardiac death can participate in low to moderate competitive sports.[28,32,68] They should have repeat echocardiograms every six months.[28,32,68] Athletes who have any aortic root dilation should only participate in low intensity sports.[28,32,68]

Long QT-syndrome: Cardiac arrhythmias account for more than 10 percent of all natural deaths. The long QT syndrome once considered a rare enigma, now provides a

molecular model that is steadily revealing the mysteries of ventricular arrhythmogenesis.[25,69,70] Long QT syndrome is an abnormality of the electrical conduction system characterized by prolonged repolarization of the ventricle with an associated high risk of sudden cardiac death.[25,69,70] This syndrome can be congenital, pharmacogenic, or metabolic. It is often defined as a corrected QT interval of more than 440 milliseconds.[25,69,70] The mechanism of sudden cardiac death is the development of wide, polymorphic tachycardia.[25,69,70] The potential fatal rhythms can be provoked by exercise-related tachycardia.[25,69,70] Long QT syndrome often manifests as syncope, seizures, or sudden death due to its peculiar polymorphic ventricular tacharrhythmia.[25,69,70]

Forty percent of patients are asymptomatic at diagnosis, 10 percent initially have cardiac arrest. Thirty percent of those with long QT syndrome were identified after ECG screening of first-degree relatives of an affected family member. Cost effectiveness of using an ECG is not valid during a cardiovascular screening for every athlete although syncope and seizures should alert the certified athletic trainer or physician to further usage of an ECG. If untreated Long QT syndrome has a ten year mortality of 50 percent.[25,69,70]

Beta blockers are used for treatment but 25 percent of long QT syndrome athletes still have arrhythmic recurrences. Controversial treatment of implantable cardioverter-defibrillator is also used in patients who suffer from long QT syndrome.[25,69,70] Athletes with long QT syndrome should be restricted from competitive sports.[25,69,70]

Commotio cordis: Commotio cordis is an electrophysiological event caused by precordial chest impact that occurs in individuals free from structural cardiac

disease.[3,71,72] Commotio cordis accounts for 20 percent of athletic field sudden deaths.[3,71,72] Commotio cordis occurs most frequently in baseball, but sudden deaths have been reported in ice hockey, lacrosse and softball. [3,71,72]

The impact generally occurs directly over the precordium and anatomical position of the heart or in a relatively localized point contact to the midchest area and is often not perceived to be of great force; the victim typically has no injury to the ribs or sternum.[3,71,72] Sudden cardiac death appears to be ventricular fibrillation that is produced when the chest impact is delivered within a narrow, electrically vulnerable period of the cardiac cycle. [3,71,72] The susceptible time is during repolarization, just before the peak of the T wave. [3,71,72] Resuscitation of these victims is possible with prompt cardiopulmonary resuscitation and defibrillation. [3,71,72] Commotio cordis registry in the United States has reported a ten percent survival rate, with a 2.8 percent experiencing full recovery. [3,71,72]

There are currently no effective measures to prevent commotio cordis. [3,71,72] The commotio cordis registry reported that only 15 percent of the victims had used some form of protective padding over a portion of the anterior chest wall at the time of injury and collapse. [3,71,72] Protective gear helps to soften and restrain blows and also helps absorb some of the energy transferred from the chest impact.

Wolff-Parkinson-White syndrome: Wolff-Parkinson-White (WPW) syndrome is estimated to occur in approximately 0.1 percent to 3 percent of the general population, and is a form of ventricular pre-excitation involving an accessory conduction pathway.[4,5,34,61,72] The definition of WPW relies on the following electrocardiographic features: 1) a PR interval less than 0.12 seconds; 2) with a slurring of the initial segment

of the QRS complex, known as a delta wave; 3) a QRS complex widening with a total duration greater than 0.12 seconds; and 4) secondary repolarization changes reflected in ST segment-T wave changes that are generally directed opposite to the major delta wave and QRS complex changes. The accessory pathway bypasses that atrioventricular node, creating a direct electrical connection between the atria and ventricles. [4,5,34,61,72]

Athletes with Wolff-Parkinson-White syndrome may have symptoms that include palpitations, syncope, and lightheadedness. When symptoms do occur they are usually secondary to tacharrhythmias; the importance of recognizing this syndrome is that these athletes may be at risk to develop a variety of supraventricular tacharrhythmias which cause disabling symptoms and even sudden cardiac death. [4,5,34,61,72] The tachyarrhthmias encountered include paroxysmal supraventricular tachycardia, atrial fibrillation, atrial flutter, and ventricular fibrillation. [4,5,34,61,72]

Wolff-Parkinson-White syndrome can almost always be cured with minimal risk of complications by catheter ablation, whereby the accessory pathway is cauterized by a catheter introduced via a blood vessel. All athletes who have symptoms and an accessory pathway should be referred for consideration of catheter ablation. [4,5,34,61,72]

Brugada syndrome: Brugada syndrome is characterized by ST-segment elevation in right precordial leads that is unrelated to ischemia, electrolyte disturbances, or obvious structural heart disease.[28,56,69,73] Brugada syndrome is a familial disease that displays an autosomal dominant mode of transmission, with incomplete penetrance and an incidence ranging between 5 and 66 per 10,000. [28,56,69,73] Brugada syndrome is unpredictable of recurrent ventricular tachycardia. Athletes may present with self-terminating episodes of ventricular tachycardia during exertion. All too often, syncope or sudden cardiac death is

the only symptom that occurs.[28,56,69,73] The underlying cause of Brugada syndrome is relayed to ventricular tachycardias. Ventricular tachycardia usually starts with a short coupling interval. It has been suggested that there is a higher than normal incidence of supraventricular tacharrhythmias, including atrial and atrioventricular reentrant tachycardia in the Brugada population.[28,56,69,73]

The diagnosis of Brugada syndrome is the appearance of a type one ST-segment elevation in more than one right precordial lead in the presence or absence of a sodium channel blocker, and one of the following likely indicates Brugada syndrome: documented ventricular fibrillation; self terminating polymorphic ventricular tachycardia; a family history of sudden cardiac death; coved type ECGs in family members; electrophysiological inducibility; syncope; or nocturnal agonal respiration.[28,56,69,73] If the diagnosis is supported by ECG findings, referral should be made for EP testing and consideration of automated implantable cardiac defibrillator placement.[28,56,69,73]

Pre-Participation Physical Examination

Pre-participation physical examination screening of athletes is customary medical practice in many high schools, colleges and universities in the United States. Through pre-participation physical examinations the medical staffs consisting of physicians and certified athletic trainers have an opportunity to evaluate and counsel a large segment of the population who may not otherwise have sought medical care. The pre-participation physical examination is not intended to exclude athletes from participation but to maintain their health and safety. The pre-participation physical examination should focus on ensuring the safety of the athlete by assessing health problems that could interfere

with athletic performance and, to the extent possible, be used as an opportunity to counsel athletes on important health issues. [27,74-82]

It is estimated that there are over eight million young athletes in the United States, and less than 0.5 percent of them are at risk for sudden cardiac death.[27,74-82] Despite these numbers, athletes should undergo pre-participation physical evaluation before the start of competitive sports. The evaluation principally consists of a history and physical examination. In the United States, it is not currently standard for electrocardiograms to be performed unless the athlete describes symptoms that warrant it. Likewise, echocardiograms are only obtained if there are symptoms or physical examination findings that are concerning. ECGs are currently routinely performed in certain areas of Italy, with a resultant reduction in sudden cardiac death from hypertrophic cardiomyopathy. [27,74-82] ECGs are not currently being obtained routinely in the United States, it is imperative that the pre-participation physical screening be performed by a health care professional who is well trained to perform a detailed cardiac history and physical examination. [27,74-82]

In athletes, the main goal of pre-participation screening is to detect previously unrecognized cardiovascular diseases that may be associated with an increased risk of sudden cardiac death. The effective use of screening tests demands thorough epidemiological evaluation. Based on pervious studies by Vasamreddy et al.[35] it has been estimated that as many as 200,000 competitive, asymptomatic athletes would need to be screened to identify a single athlete who would die as a result of competition. However, identification of these diseases may well prevent or delay some cases of sudden death

because of physician recommended temporary or permanent withdrawal from sports or treatment interventions.[18,23,81]

Hypertrophic cardiomyopathy is the most common cause of sudden cardiac death in young athletes, most studies have focused screening efforts on the detection of this disease. In addition to a thorough history and physical examination, echocardiography has regularly been proposed as an effective screening tool, because of its high reported sensitivity and specificity. Although several studies have applied echocardiography to screening large athletic populations, most have been associated with high cost. The American Heart Association consensus panel stipulated that such pre-participation cardiovascular screening is a justifiable clinical practice, but routine noninvasive testing is not recommended due to the low anticipated yield and associated cost efficacy considerations.[27,74-82] This process primarily focuses on the identification of historical and physical features associated with increased risk. [27,74-82]

History: The pre-participation physical examination is the backbone of the screening process, identifying up to 75 percent of medical problems.[27,74-82] Athletes often do not recognize that symptoms they have experienced are of significance, which is why taking a thorough cardiac history is important. [27,74-82] Careful attention to the cardiac history is warranted because several of the conditions known to cause sudden cardiac death such as arrhythmias or coronary artery disease have no auscultatory findings. [27,74-82]

Symptoms of dizziness, lightheadedness or syncope during or after exercise may indicate underlying hypertrophic cardiomyopathy, conduction abnormalities, arrhythmias or valvular problems such as mitral valve prolapse. [27,74-82] Chest pains during or after exercise may indicate a coronary artery anomaly or advanced cardiovascular disease.[27,74-

[82] Dyspnea that is out of proportion to activity may indicate structural abnormalities or valve problems. [27,74-82] Palpitations during or after exercise may signal arrhythmias or conduction abnormalities. A history of high blood pressure, high cholesterol levels or recent viral illness may indicate myocarditis. [27,74-82] Prior restriction from participation in sports for cardiovascular reasons warrant further investigation. A history of heart murmur merits concern, although a benign murmur may be detected on examination of many athletes pertaining to the athlete's heart. [27,74-82] Family history should be explored for a history of sudden death or congenital heart anomalies. A family history of sudden death before age 50 is extremely important, as some causes of death can be familial premature coronary artery disease, Marfan's syndrome, and hypertrophic cardiomyopathy. [27,74-82] Finally, it is important to question the athlete about the use of anabolic steroids, cocaine, and other illicit drugs. Any concerning history that is elicited is reason to obtain an electrocardiogram and refer the athlete to a cardiologist. [27,74-82]

Physical examination: Physical examination of the athlete should begin with measurement of the brachial pulse and blood pressure. Young athletes often have low resting heart rates and blood pressure; as such, resting tachycardia or hypertension is reason for concern. Precordial auscultation should then be performed, both supine and standing. Standing decreases venous return to the heart and alters the characteristics of different murmurs. [27,74-82] Murmurs should be evaluated on the basis of intensity, loudness, location and timing during the cycle. Any systolic murmur grade 3/6 or higher, any diastolic murmur, and any murmur that gets louder with the Valsalva maneuver should be evaluated further before the athlete is cleared for participation. [27,74-82] The femoral pulses should be palpated and compared with the brachial pulse. A diminished

femoral pulse is suggestive of congenital coarctation of the aorta. Athletes should be examined for characteristics of Marfan's disease.[27,74-82] General screening also includes musculoskeletal systems, eyes, oral cavity, ears, nose, lungs, abdomen, genitalia (males) and skin. Anthropometic measurement includes height, weight, and blood pressure.[27,74-82]

Medical clearance: When a significant cardiovascular problem is identified, management decisions must include the magnitude of that person's risk for sudden cardiac death with continued participation in competitive sports and whether the athlete should be disqualified from such participation.[27,74-86] In addition to clinical judgment, physician decisions regarding clearance for a particular sport may be based on guidelines established by the 36th report of the Bethesda Conference (refer to Table B2). The focus of the 36th Bethesda Conference is on the trained athlete with an identified cardiovascular abnormality.[84] The goal is to formally develop prudent consensus recommendations regarding the eligibility of such individuals for competition in organized sports, and to present these considerations in a readily usable format for clinicians.[27,74-86]

Table B3. 36th Bethesda Conference Recommendations [84-86]

Diagnosis	Recommendation
HCM	1. Should not participate in most competitive sports 2. Possible participation in low intensity sports
CAA	1. Should be excluded from competitive sports 2. Athletes without ischaemia on exercise testing may participate in sports >3 months after surgical treatment
Myocarditis	1. Should be withdrawn from competitive sports for about 6 months after onset of symptoms for convalescence 2. May return to competitive sports after normalization of ventricular function and absence of clinically relevant arrhythmias on ambulatory ECG monitoring
ARVD	1. Should only participate in low intensity sports
Marfan's	1. Athletes without a family history of premature sudden cardiac death and without aortic root dilatation can participate in low and moderate intensity competitive sports. Serial 6 monthly monitoring of aortic root should be repeated 2. Athletes with aortic root dilatation can participate in low intensity sports only

WPW	1. Athletes without structural heart diseases, palpitations or tachycardia can participate in all competitive sports 2. Athletes with successful ablation of accessory pathway who are asymptomatic, have normal atrioventricular conduction on electrophysiological study, and have no recurrence of tachycardia for 3-6 months can participate in all sports.
Long QT	1. Should only participate in low intensity sports
Brugada	1. Should not participate in competitive sports
MVP	1. If considered low risk can participate all sports. Should be re-evaluated annually

Key: HCM=Hypertrophic Cardiomyopathy; CAA=Coronary Artery Anomalies; ARVD=Arrhythmic Right Ventricular Dysplasia; WPW=Wolff-Parkinson-White syndrome; MVP=Mitral Valve Prolapse

The Bethesda Conference determines eligibility for competition. Any restriction to activity should be fully explained to the athlete, parents, coaching staff, and other university personnel. Physicians and certified athletic trainers who perform the pre-participation physical examination should inform athletes and their parents of the limitations of cardiovascular screening and the risks associated with the findings. [27,74-86]

The Bethesda Conference updated from the previous 1994 26th Conference to the 36th Conference in 2005.[84] The revision of the 26th Conference guidelines were due to the substantial advances that have taken place in the diagnosis and management of a variety of genetic and acquired cardiovascular diseases, in the recognition of the causes of athletic field deaths, and in ethical and legal issues that impact medical decision making.[84] Also, sudden cardiac deaths in competitive athletes continue to be highly visible, compelling, and emotional events with significant liability considerations.[84]

In 1994, when the 26th Bethesda Conference recommendations were formulated (refer to Table B3), no court had yet considered whether an athlete with a cardiovascular abnormality could be involuntarily excluded from a competitive sport if physicians disagreed in their participation recommendations.[85] However, new data have

subsequently become available, and several highly visible cases involving the sudden deaths of elite competitive athletes have brought medical-legal and liability consideration into prominent focus.[85] Consequently, judicial precedent now provides some guidance regarding the role of the present 36th Bethesda Conference recommendations in resolving legal issues to athletic participation disputes.[85]

Table B2. 26th Bethesda Conference Recommendations [84-86]

Diagnosis	Recommendation
HCM	1. Should not participate in most competitive sports with the possible exception of those of low intensity 2. Older athletes may participate depending on risk factor stratification
ARVC	1. Should not participate in competitive sports
CAA	1. Should be excluded from competitive sports 2. Athletes without ischaemia on exercise testing may participate in sports >6 months after surgical treatment
WPW	1. Athletes without structural heart disease, palpitations or tachycardia can participate in all competitive sports 2. Athletes with re-entrant tachycardia should be treated with radiofrequency ablation 3. Athletes with atrial flutter/fibrillation with slow accessory pathway conduction and no syncope can participate freely. Those with syncope or fast accessory pathway conduction should be treated with radiofrequency ablation. 4. Athletes with successful ablation of accessory pathway who are asymptomatic, have normal atrioventricular conduction on electrophysiological study, and have no recurrence of tachycardia for 3-6 months can participate in all sports.
Ion Channelopathies	1. Should not participate in competitive sports
IDCM	1. Should not participate in competitive sports
Premature Coronary Artery Disease	1. If considered low risk, can participate in low and moderate intensity sports. Should re-evaluated annually. 2. If considered to be at high risk, may only participate in low intensity sports. Should re-evaluate every 6 months.
Marfan's Syndrome	1. Athletes without a family history of premature sudden cardiac death and without aortic root dilatation can participate in low and moderate intensity competitive sports. Serial 6 monthly monitoring of aortic root should be repeated. 2. Athletes with aortic root dilatation can participate in low intensity sports only
Myocarditis	1. Should be withdrawn from competitive sports for about 6 months after onset of symptoms for convalescence 2. May return to competitive sports after normalization of ventricular function and absence of clinically relevant arrhythmias on ambulatory ECG monitoring

Aortic Stenosis	1. Athletes with mild aortic stenosis (<20 mmHg) can participate in all competitive sports 2. Athletes with mild to moderate aortic stenosis (21 to 40 mmHg) can participate in all low intensity sports. Some, depending on exercise stress testing, can participate in low and moderate intensity sports 3. Athletes with severe aortic stenosis (>40 mmHg) or symptoms should not engage in any competitive sports 4. Athletes with bicuspid aortic valve, even without stenosis but with aortic dilatation, can participate in low intensity sports only. Serial 6 monthly echocardiographic monitoring of aortic root and ascending aorta is recommended.

Key: HCM=Hypertrophic Cardiomyopathy; ARVC=Arrhythmic Right Ventricular Cardiomyopathy; CAA= Coronary Artery Anomalies; WPW=Wolff-Parkinson-White syndrome; IDCM=Idiopathic Dilated

Controversy European Protocol vs. United States Protocol

The extent of screening that is needed in the pre-participation evaluation to prevent sudden cardiac death is controversial.[7,42] The impact of sudden death in a young athlete during competition always drives the question as to what more could have been done to identify this person who, apparently, was at a higher risk. [7,42,82] Use of screening tests, however, should be evaluated by epidemiologic criteria for determining effectiveness.

Attempts have been made to put screening strategies for the prevention of sudden death into perspective by estimating disease prevalence. It has been estimated that 200,000 competitive asymptomatic athletes would need to be screened to potentially identify one athlete who would die as a result of competition. [7,42,82] One of the problems with screening athletes is the abnormalities detected during examinations may merely be normal variants. The well trained athlete often demonstrates electrocardiographic, radiographic and echocardiographic changes of cardiac enlargement and enhanced vagal tone. [7,42,82]

Both the American Heart Association (AHA) and the Sports Cardiology Study group of the European Society of Cardiology recommend screening high school and college athletes before athletic participation. Both guidelines recommend a personal and family history as well as a physical examination, but the European guidelines recommend obtaining routine electrocardiograms. Both recommendations are based primarily on consensus opinion because there are few, if any, prior large studies of screening protocols that provide mortality data.[82]

Corrado et al.[13] reported findings supporting the cardiovascular screening of athletes and the European approach of routinely requiring ECGs. Italy has had a national mandated pre-participation screening program for athletes since 1982. The annual incidence of sudden cardiac death in athletes decreased from 3.6 deaths per 100,000 person-years in 1979-1980 to 0.4 deaths per 100,000 person-years in 2003-2004, an 89 percent reduction. [13,82] Most of the decrease in death was due to fewer deaths attributable to cardiomyopathies, whereas the number of athletes disqualified because of cardiomyopathies increased. Both the decrease in deaths and the increase in disqualifications were primarily due to changes in the frequency of arrhythmogenic right ventricular cardiomyopathy. Of the 42,386 screened athletes, 3,914 (9 percent) required additional cardiovascular testing and 879 (2 percent) were ultimately prohibited from athletic participation. [13,82] This pre-participation screening essentially based on 12-lead ECG can detect individuals with hypertrophic cardiomyopathy as well as long QT syndrome but with relatively low specificity.[13,27,79-82]

Pre-participation cardiovascular screening has traditionally been performed in the United States by means of history and physical examination without 12-lead ECG or

other testing. This screening method has been recommended by the American Heart Association on the assumption that 12-lead ECG is not cost effective for screening a large population of young athletes due to its low specificity. Such a screening strategy, however has a limited power to detect potentially lethal cardiovascular abnormalities in young athletes. One retrospective analysis on 134 collegiate athletes who died suddenly showed that cardiovascular abnormalities were suspected by standard history and physical examination screening in only three percent of the examined athletes and, eventually, less than one percent received an accurate diagnosis. [20,21,23,81,82]

The addition of 12-lead ECG has the potential to enhance the sensitivity of the screening process for detection of cardiovascular diseases with risk of sudden death. Abnormal ECG is found in up to 95 percent of patients with hypertrophic cardiomyopathy, which is the leading cause of sudden cardiac death in athletes. [20,21,23,81] Likewise, ECG abnormalities have also been documented in the majority of athletes who died from arrhythmogenic right ventricular dysplasia.

Although diagnostic tools such as ECGs and echocardiography may identify a small number of individuals at risk for sudden cardiac death, the emotional and financial costs are high given the limits on the screening instruments currently available. Screening all athletes with echocardiography would certainly identify many potential causes of sudden cardiac death but at an astounding financial cost. Instituting such a protocol nationwide would be difficult due to the limited availability of testing. Screening by ECG is less expensive, but relates a high false-positive rate. Diagnosing should rely on the 2007 updated recommendations of the American Heart Association guidelines and disqualifications should be based on the 36th Bethesda Conference.[20,21,23,81]

American Heart Association Recommendations for Pre-Participation Cardiovascular Screening

In 1996, the American Heart Association expert consensus panel recommended pre-participation screening to competitive athletes limited to the personal and family history and physical examination; routine diagnostic tests, including the ECG, were excluded largely based on cost-efficacy considerations (refer to Table B4).[17,18,22,23,73,76] The panel recognized that these recommendations may not necessarily be relevant to other societies and were compelled only to offer guidelines consistent with the reality of pre-participation screening in the United States.[17,18,21-23,73,76] On the other hand, the American Heart Association consensus panel preferred to promote a standardized national medical examination form to improve the existing system of history and physical examination screening recommending that the examination be conducted every two years. Thus, promoting the identification of a higher number of athletes with important cardiovascular abnormalities.[76] The American Heart Association has issued the nation's first set of recommendations for the screening of young athletes for potentially fatal cardiovascular disease.[17,18,21-23,73,76]

Table B4. 1996 American Heart Association Recommendations [18,21]

History
- Previous occurrence of chest pain
- Discomfort of syncope
- Near syncope
- Excessive, unexpected, and unexplained shortness of breath or fatigue associated with exercise
- Past detection of a heart murmur or increased systolic blood pressure
- Family history of premature death or significant disability from cardiovascular disease in close relatives younger than 50 years of age
- Specific knowledge of the occurrence of certain conditions:
  - Hypertrophic cardiomyopathy
  - Dilated cardiomyopathy
  - Marfan's syndrome
  - Long QT syndrome
  - Clinically important arrhythmias

Examination
- Precordial auscultation in supine and standing positions to identify heart murmurs
- Assessment of femoral arteries to exclude coarctation of the aorta

- Recognition of the physical stigmata of Marfan's syndrome:
- Brachial blood pressure measurement in seated position

Although sudden death among athletes is rare, its occurrence always raises the question of whether the death of an apparently healthy young athlete could have been prevented by medical evaluation. Yet it is virtually impossible to detect all potentially fatal heart conditions through pre-participation screening.[17,22,23,76]

In 2007, the American Heart Association updated their cardiovascular recommendations based on evaluations from previous studies of sudden cardiac death among athletes.[21] The present 2007 AHA recommendations for personal and family history and physical examination are promoted by the panel as a potentially effective strategy to raise the suspicion of cardiovascular disease in both large and small screening populations of high school and college student-athletes (refer to Table B5).[21]

Table B5. 2007 American Heart Association Recommendations[21]

Medical History

Personal History

1. Exertional chest pain/discomfort
2. Unexplained syncope/near-syncope
3. Excessive exertional and unexplained dyspnea/fatigue, associated with exercise
4. Prior recognition of a heart murmur
5. Elevated systemic blood pressure

Family History

6. Premature death (sudden and unexpected, or otherwise) before age 50 years due to heart disease
7. Disability from heart disease in a close relative <50 years of age
8. Specific knowledge of certain cardiac conditions in family members: hypertrophic or dilated cardiomyopathy, long QT syndrome or other ion channelopathies, Marfan syndrome, or clinically important arrhythmias

Physical Examination

9. Heart murmur (both in supine and standing position)
10. Femoral pulses to exclude aortic coarctation
11. Physical stigmata of Marfan syndrome
12. Brachial artery blood pressure (sitting position)

The 2007 AHA recommendations included areas of significance from 1996 and developed twelve items for cardiovascular screening (eight for personal and family history and four for physical examination).[21] Implementation of the twelve guidelines

into the physical examination may help the medical personnel spot athletes that may be at risk for sudden cardiac death.[21] The AHA recommends the cardiovascular screening examination be performed once upon entrance which differs from the 1996 recommendations. The AHA feels that the number of sudden cardiac deaths might be lowered significantly with a more thorough history and physical examination be performed.[21]

NCAA Compliance with American Heart Association Recommendations

The National Collegiate Athletic Association (NCAA) mandated that prior to participation in any physical activity (preseason, regular season, non-traditional season) all prospects, walk-ons, and student-athletes shall be required to undergo a medical examination that is administered or supervised by a physician.

The Committee on Competitive Safeguards and Medical Aspects of Sports believes before student-athletes accept the rigors of organized sport, their health should be evaluated by qualified medical personnel. The intent is to ensure all participants have a medical examination upon entrance to the sport. During subsequent years, an interim history should be performed upon which a physician would determine if additional physical, cardiovascular or neurological examinations are required. Currently, there is an inconsistency as to when student-athletes receive physicals and variability in the type of exams. The committee recommends that all student-athletes should have a pre-participation examination consistent with the legislation for the sport of football under NCAA Bylaw 17.11.2.2 Activities Prior to First Practice Date. Due to the inconsistency in medical forms used nationwide, the committee highly recommends the forms within the "Pre-participation Physical Examination" monograph as a minimal standard. The

NCAA has recommended ten of the twelve recommended history and physical examination items promoted by the AHA, omitting only a history of fatigability and Marfan stigmata on examination.[21] Each institution should provide its own pre-participation examination form based on these minimal standards, which includes a thorough history, physical examination and screening for cardiovascular conditions.

Pfister et al. [23] surveyed questionnaires to the team physician or the athletic director or athletic trainer of the 1110 National Collegiate Athletic Association colleges and universities between 1995 and 1997 to assess screening practices for detecting potentially lethal cardiovascular diseases in college-aged student-athletes. The screening forms were analyzed and compared to a selected twelve AHA recommendations from 1996 that Pfister et al. [23] complied. Of the 1110 NCAA institutions initially surveyed, 879 (79 percent) returned the questionnaire including 286 Division I, 256 Division II, and 337 Division III. A total of 855 of the 879 schools indicated that formal screening with a personal family history and physical examination was an absolute requirement prior to participation in varsity intercollegiate sports.

The most recent versions of the screening history and physical examination forms were obtained from 625 institutions. Of these, 205 (33 percent) were from NCAA Division I, 176 (28 percent) were from Division II, and 244 (39 percent) were from Division III schools. Forms arbitrarily regarded as adequate by containing at least 9 of the selected 12 AHA- recommended items were present for 163 (26 percent), including 10 institutions with 11 or 12 items. In contrast, forms arbitrarily judged to be inadequate with 4 or less of the selected 12 AHA recommendations came from 150 schools (24 percent), including 46 with only 0 to 2 items. The remaining 312 schools (50 percent)

used forms that were intermediate by virtue of addressing 5 to 8 selected 12 AHA recommendations. Inadequate forms were more frequent in NCAA Division II and Division III schools and less common in Division I.

In a parallel study using college athletes, Pfister et al [23] compared screening procedures against the selected 12 AHA recommendations. The authors found that only 26 percent of the colleges and universities had forms that contained 9 of 12 recommended items and thus were judged to be adequate. Twenty four percent of the schools had forms that contained 4 or fewer of the recommended items.

In 2001, a follow up study by Koester [20] compared the NCAA with the selected 12 American Heart Association guidelines, only 26 percent of NCAA schools were found to be using "adequate" history and physical examination forms containing at least 9 of 12 recommended items. NCAA Division II and Division III schools 28 percent and 30 percent, respectively were found to have inadequate forms containing 4 or fewer of the 12 recommended items more often than Division I schools by 14 percent. Only 9 to 52 percent of the history and physical screening forms pertinent to the cardiovascular system were relevant to the American Heart Association. Approved physical examination forms also demonstrated important omissions such as examination of the femoral pulses and recognition of Marfan's stigmata.

In conclusion the pre-participation screening process used by many in the United States colleges and universities have limited potential in detection or raising suspicion of cardiovascular abnormalities causing sudden cardiac death in college athletes. When examinations are conducted in accordance with the American Heart Association

recommendations by appropriately trained practitioners, potentially serious cardiac pathologic conditions may be detected.

Summary

Sudden cardiac death is defined as a nontraumatic, nonviolent, unexpected death due to cardiac causes within one hour of the onset of symptoms, or within six hours of witnessed normal state of health.[10,13,37,38] The major mechanisms involved in sudden cardiac death are related haemodynamic and electrophysiological changes brought about by exercise in the susceptible individual.[35,37,44,45]

The most common diseases associated with sudden cardiac death to young athletes are: hypertrophic cardiomyopathy and congenital coronary artery anomalies.[1,2,12,46] Hypertrophic cardiomyopathy is the most common cause of sudden cardiac death for at least 36 percent of deaths among young athletes. [1,2,12,46] The disease is characterized by abnormal diastolic filling and obstruction to left ventricular outflow. [1,2,12,46] Congenital coronary artery anomalies is often triggered by nonatherosclerotic coronary artery disease, either acquired or congenital in orgin.[51] Less common causes of sudden cardiac death in young athletes are arrhythmogenic right ventricular dysplasia, myocarditis, mitral valve prolapse, Marfan's syndrome, long QT syndrome, commotion cordis, Wolff-Parkinson-White syndrome, and Brugada syndrome.[54-57]

Pre-participation physical examination screening of athletes is customary medical practice in colleges and universities. The pre-participation physical examination focuses on ensuring the safety of the athlete by assessing health problems that could interfere

with athletic performance.[74-82] United States and Europe differ on pre-participation protocols. The European protocol mandates cardiovascular screening with non-invasive testing 12-Lead ECG along with history and physical examination. The United States recommends inclusion of a cardiovascular screening in pre-participation physical examinations with history and physical exam. In 2007, American Heart Association recommended twelve guidelines to follow for cardiovascular screening of athletes. The twelve guidelines include medical family and personal history and physical examination. The NCAA requires a pre-participation physical examination for initial athletes. The NCAA recommends a cardiovascular screening using ten of the twelve recommended AHA guidelines leaving the discretion to each individual institution.

APPENDIX C

ADDITIONAL METHODS

Table C1. Initial Email to Recipients

October 16, 2007

Dear Head Athletic Trainer,

This message is a request to participate in a research study being conducted by the primary investigator (PI) Michelle A. Sandrey PhD, ATC and Co-PI Jennifer Street ATC, a Graduate Athletic Training student. Both are affiliated with West Virginia University. Participation will require you to answer a 24-question survey. The main purpose of this study is to determine if NCAA Division I, II, and III institutions have increased from previous studies the number of recommended American Heart Association guidelines into the cardiovascular examination. This thesis is being completed to partially fulfill requirements for the completion of a Master of Science Degree in Athletic Training at West Virginia University.

The following survey includes 24 multiple choice questions on demographics, pre-participation physical examination, medical history, physical examination, and referral. You do not have to answer all the questions. You may withdraw from the study at any time with no penalty. The survey should take approximately 10 minutes to complete. Please go to the following website to take the survey:
http://simpleforms.scripts.wvu.edu/sf/CardioScreeningSurvey/

Your involvement in this survey will be kept completely anonymous for the duration of the study. I will not ask you to include your name on any of the questions nor will I present any information at any time that could allow for individual participants to be identified. You may withdrawal with no penalty any time throughout the study.

I respectfully request that you participate in this study, as it could be very beneficial for the academic and athletic communities alike to further their knowledge and understanding of cardiovascular conditions and sudden cardiac death among collegiate athletes. I would like to thank you very much for your time. If you should have any questions regarding this email, survey, or study in general, please feel free to contact me Jennifer Street ATC at (614)746-5611 or jstreet1@mix.wvu.edu or Dr. Michelle A. Sandrey at (304)293-3295 ext 5220 or msandrey@mail.wvu.edu.

Thank you very much, in advance, for your participation in this study.
Sincerely,

Jennifer Street, ATC
*WVU IRB acknowledgement of this study is on file

Table C2. Follow-up Email

October 30, 2007

Dear Head Athletic Trainer,

This message is a request to participate in a research study being conducted by the primary investigator (PI) Michelle A. Sandrey PhD, ATC and Co-PI Jennifer Street ATC, a Graduate Athletic Training student. Both are affiliated with West Virginia University. Participation will require you to answer a 24-question survey. The main purpose of this study is to determine if NCAA Division I, II, and III institutions have increased from previous studies the number of recommended American Heart Association guidelines into the cardiovascular examination. This thesis is being completed to partially fulfill requirements for the completion of a Master of Science Degree in Athletic Training at West Virginia University.

The following survey includes 24 multiple choice questions on demographics, pre-participation physical examination, medical history, physical examination, and referral. You do not have to answer all the questions. You may withdraw from the study at any time with no penalty. The survey should take approximately 10 minutes to complete. Please go to the following website to take the survey:
http://simpleforms.scripts.wvu.edu/sf/CardioScreeningSurvey/

Your involvement in this survey will be kept completely anonymous for the duration of the study. I will not ask you to include your name on any of the questions nor will I present any information at any time that could allow for individual participants to be identified. You may withdrawal with no penalty any time throughout the study.

I respectfully request that you participate in this study, as it could be very beneficial for the academic and athletic communities alike to further their knowledge and understanding of cardiovascular conditions and sudden cardiac death among collegiate athletes. I would like to thank you very much for your time. If you should have any questions regarding this email, survey, or study in general, please feel free to contact me Jennifer Street ATC at (614)746-5611 or jstreet1@mix.wvu.edu or Dr. Michelle A. Sandrey at (304)293-3295 ext 5220 or msandrey@mail.wvu.edu. This is a follow-up email to let you know there is still time to fill out the survey. Thank you as this is just a reminder email

Thank you in advance for your participation in this study.

Sincerely,

Jennifer Street, ATC
* WVU IRB acknowledgement of this study is on file

Table C3. Survey

Please answer the following questions honestly and to the best of your ability. If you have selected other as a response, please include a response. Please click or type in response in box. After completion please submit.

1. What NCAA Division are you currently working for?
   - o I
   - o II
   - o III

2. What is the approximate undergraduate student enrollment at your institution?_____

3. What is the approximate number of student-athletes?_____

4. What is the total number of varsity intercollegiate sports?_____

5. How important is a cardiovascular screening within your pre-participation screenings (least from least important to most important)

Not at all important		Moderately		Very Important	
1	2	3	4	5	6

6. Are you aware of the NCAA 10 recommendations for cardiovascular screening?
   - o Yes
   - o No

7. Are you aware of the 2007 AHA recommendations for cardiovascular screening?
   - o Yes
   - o No

Pre-Participation Exam (PPE) Information

8. Do you require a PPE with a cardiovascular screening section for incoming student athletes prior to participation?
   - o Yes
   - o No
   - o Unsure

9. How often do student-athletes receive a PPE?
   - o Once (upon entrance)
   - o Yearly
   - o Every two years
   - o Other _____

10. Who is primarily responsible for administering the PPE? (select one)
    - o ATC
    - o University Team Physician
    - o Non-University Physician
    - o Other _____

11. If a team physician is involved in the administration of PPE's, in what area does he/she specialize? (select all that apply)
    - o General Practitioner
    - o Orthopedics
    - o Internal Medicine
    - o Cardiology
    - o Pediatrics
    - o None of the above- no team physician is involved
    - o Other _____

12. What other professionals are involved in the administration of PPE's? (select all that apply)
    - o ATC
    - o Athletic Training Student
    - o Team Physician
    - o Physician's Assistant
    - o Nurse Practitioner
    - o Chiropractor
    - o General Practitioner
    - o Cardiologist
    - o Physical Therapist

Medical History Form

13. Are student-athletes required to complete a medical family and personal history form annually?
    - o Yes
    - o No
    - o Unsure

14. Which of the following conditions are listed on the medical history personal portion of the form? (select all that apply)
    - o Exertional chest pain/discomfort
    - o Unexplained syncope/near-syncope
    - o Excessive exertional and unexplained dyspnea/fatigue associated with exercise
    - o Prior recognition of a heart murmur
    - o Elevated systemic blood pressure
    - o None of the above (proceed to #15)

14a. Who developed the cardiovascular portion of the medical history form? (select all that apply)
    - o ATC(s)
    - o University Team Physician
    - o Athletic Director
    - o Other_____
    - o Not Sure
    - o None of the above
    - o Not applicable- the medical history form does not include a cardiovascular portion

14b. Where did you obtain your information of what to include in the cardiovascular portion of the medical history form?
    - o American Heart Association
    - o NCAA
    - o American Medical Association
    - o Other____
    - o Not Sure
    - o None of the above
    - o Not applicable- the medical history form does not include a cardiovascular portion

Physical Cardiovascular Examination

If not administered by ATC please check with who evaluates this section

15. Which of the following are performed during the physical exam? (select all that apply)
    - o Precordial auscultation supine
    - o Precordial auscultation sitting
    - o Precordial auscultation standing
    - o Palpation of femoral pulse
    - o Physical stigmata of Marfan syndrome
    - o Brachial artery blood pressure
    - o None of the above (proceed to #16)

    15a. Where did you obtain your information of what to include in the cardiovascular portion of the physical exam? (select all that apply)
    - o American Heart Association
    - o NCAA
    - o American Medial Association
    - o Other _____
    - o None of the above
    - o Not applicable- the physical exam does not include cardiovascular procedures

16. Are any of the following non-invasive cardiovascular tests performed during a standard PPE on all student-athletes? (select all that apply)
    - o 12-Lead ECG
    - o Echocardiogram
    - o Stress Test
    - o Other _____
    - o None of the above

Referral

17. Have you ever referred a student athlete for further examination based on cardiovascular screening during a PPE?
    - o Yes (go to #18)
    - o No (go to #21)
    - o Unsure (go to #21)

18. Approximately how many student athletes per year are referred for further examination based on cardiovascular screening?_____

19. To whom do you refer these athletes?
    - o Team Physician
    - o General Practitioner
    - o Cardiologist
    - o Other _____

20. Of those athletes referred, how many per year are:
    - o Disqualified from participation _____
    - o Allowed to participate with modifications _____
    - o Allowed to participate fully _____

Demographics

21. Gender:
    - o Male
    - o Female

22. What is your current job title? _____

23. What is your highest level of education?
    - o Bachelors
    - o Graduate Degree
    - o Post Graduate Degree
    - o Other _____

24. What certification(s) do you hold? (select all that apply):
    - o ATC
    - o PT
    - o CSCS
    - o PES
    - o LMT
    - o EMT
    - o None of the above
    - o Other _____

Additional Comments-

Thank you for your participation.

APPENDIX D

ADDITIONAL RESULTS

Table D1. Demographic Characteristics of Survey Respondents (N=327)

	Division I (103/31.5%)	Division II (91/27.8%)	Division III (133/40.7%)	Overall (327/100%)
Gender				
Male	77(74.8%)	57(62.6%)	69 (51.99%)	203(62.1%)
Female	11(10.7%)	21(23.1%)	48 (36.1%)	80 (24.5%)
Job Title				
Director	26(28.9%)	7(8.9%)	3 (2.5%)	36 (12.5%)
Head	60(66.7%)	70(88.6%)	108(90%)	238(82.4%)
Education				
Bachelors	7(7.8%)	2(2.6%)	12 (10%)	21 (7.3%)
Graduate	70(77.8%)	65(83.3%)	94 (78.3%)	229(79.5%)
Post	12(13.3%)	10(12.7%)	10 (8.3%)	32 (11.1%)
Certification				
ATC	89(98.9%)	76(97.4%)	113(95%)	278(96.9%)
CSCS	5(5.6%)	13(16.7%0	17(14.3%)	35(12.2%)
PES	4(4.4%)	2(2.6%)	9(7.6%)	15(5.2%)
EMT	7(7.8%)	5(6.4%)	4(3.4)	16(5.6)

Table D2. NCAA Institutions Cardiovascular Screening Information

	Division I (103/31.5%)	Division II (91/27.8%)	Division III (133/40.7%)	Overall (327/100%)
Cardiac Screening				
Yes	101(98.1%)	91(100%)	130(97.7%)	322(98.5%)
No	2(1.9%)	0(.0%)	3(2.3%)	5(1.5%)
Information				
AHA	35(37.2%)	23(27.4%)	28(22.4%)	86(28.4%)
NCAA	42(44.7%)	31(36.8%)	40(32%)	113(37.3%)
AMA	33(35.1%)	22(26.2%)	27(21.6%)	82(27.1%)
Non-Invasive Testing				
12-Lead ECG	8(8.3%)	1(1.2%)	1(0.8%)	10(3.3%)
Echocardiogram	4(4.2%)	3(3.7%)	1(0.8%)	8(2.6%)
Stress Test	0(.0%)	2(2.4%)	2(1.6%)	4(1.3%)

Key :AHA=American Heart Association; NCAA=National Collegiate Athletic Association; AMA=American Medical Association

Table D3. Percentage of PPE Information

	Division I (103/31.5%)	Division II (91/27.8%)	Division III (133/40.7%)	Overall (327/100%)
Occurrence				
Once	44(42.7%)	35(38.5%)	48(36.1%)	127(38.8%)
Yearly	55(53.4%)	52(57.1%)	79(59.4%)	186(56.9%)
Every Two	4(3.9%)	4(4.4%)	6(4.5%)	14(4.3%)
Administering				
ATC	4(3.9%)	23(25.3%)	19(14.3%)	46(14.1%)
Team Phys	89(86.4%)	44(48.4%)	54(40.6%)	187(57.2%)
Non-Team	11(10.7%)	25(27.5%)	63(47.4%)	99(30.3%)
Specialization				
General	81(78.6%)	57(62.6%)	68(51.1%)	206(63%)
Orthopedic	54(52.4%)	41(45.1%)	50(37.6%)	145(44.3%)
Cardiologist	6(5.8%)	4(4.4%)	1(0.8%)	11(3.4%)
Other Professionals				
ATC	90(87.4%)	77(84.6%)	90(67.7%)	257(78.6%)
ATS	52(50.5%)	39(42.9%)	44(33.1%)	135(41.3%)
Team Phys	61(59.2%)	45(49.5%)	41(30.8%)	147(45%)
PT	18(17.5%)	10(11%)	6(4.5%)	34(10.4%)

Table D4. Percentage of American Heart Association Guidelines Implemented By NCAA Institutions

	Division I (103/31.5%)	Division II (91/27.8%)	Division III (133/40.7%)	Overall (327/100%)
Medical History	92(89.3%)	85(93.4%)	123(92.5%)	300(91.7%)
Medical History Exam				
ECPD	91(88.3%)	74(81.3%)	105(78.9%)	270(82.6%)
USNS	79(76.7%)	61(67%)	91(68.4%)	231(70.6%)
EEUE	77(74.8%)	69(75.8%)	90(67.7%)	236(72.2%)
PHM	89(86.4%)	84(92.3%)	107(80.5%)	280(85.6%)
ESBP	82(79.6%)	59(64.8%)	85(63.9%)	226(69.1%)
Physical Exam				
PCA	69(67%)	56(61.5%)	59(44.4%)	184(56.3%)
FP	17(16.5%)	13(14.3%)	17(12.8%)	47(14.4%0
MS	44(42.7%)	27(29.7%)	26(19.5%)	97(29.7%)
BABP	66(64.1%)	58(63.7%)	73(54.9%)	197(60.2%)

Key: ECPD=Exertional chest pain/discomfort; USNS=Unexplained syncope/near-syncope; EEUE=Excessive exertional and unexplained dyspnea; PHM=Prior recognition heart murmur; ESBP= Elevated systemic blood pressure; PCA=Precordial auscultations; FP=Femoral pulse; MS=Marfan's stigmata; BABP=Brachial artery blood pressure

Table D5. Percentage of Referrals By NCAA Institutions

	Division I (103/31.5%)	Division II (91/27.8%)	Division III (133/40.7%)	Overall (327/100%)
Referral				
Yes Referred	88(85.4%)	72(79.1%)	92(69.2%)	252(77.1%)
No Referral	2(1.9%)	4(4.4%)	24(18%)	30(9.2%)
Approximately				
0-10	83(80.6%)	70(76.9%)	96(72.2%)	249(76.1%)
11-20	11(10.7%)	16(17.6%)	33(24.8%)	60(18.3%)
21-30	7(6.8%)	5(5.5%)	3(2.3%)	15(4.6%)
31+	2(1.9%)	0(.0%)	1(0.8%)	3(0.9%)
Professional				
General	2(2.2%)	11(14.1%)	13(13%)	26(9.6%)
Team Phys	7(7.6%)	13(16.7%)	14(14%)	34(12.6%)
Cardiologist	81(90%)	50(64.1%)	63(63%)	194(72.4%)

Table D6. NCAA Divisions by AHA Recommendations

Division	Inadequate	Moderate	Adequate	χ^2	P	CC
NCAA I (n=103)	4.9%	39.8%	55.3%	11.429	.022	.184
NCAA II (n=91)	5.5%	46.2%	48.4%	11.429	.022	.184
NCAA III (n=133)	9.8%	55.6%	34.6%	11.429	.022	.184
Overall (n=327)	7.0%	48.0%	45.0%	11.429	.022	.184

Sig. $P \leq .05$, χ^2=Pearson Chi-Square, CC=Cotingency Coefficient

APPENDIX E

RECOMMENDATIONS FOR FUTURE RESEARCH

1. Repeat the study comparing responses of team physicians to certified athletic trainers.

2. Survey certified athletic trainers' knowledge of the updated 2007 recommended American Heart Association guidelines and the NCAA recommendations for cardiovascular screening procedures

3. Survey certified athletic trainers' knowledge of cardiovascular conditions among young athletes.

4. Survey certified athletic trainers' on the cardiovascular conditions that the athletes were diagnosed with and the treatment and return to play criteria that was used compared to the 36th Bethesda Conference guidelines.

5. Repeat the study surveying athletic directors of high schools across the United States comparing pre-participation physical examinations to the updated 2007 recommended American Heart Association guidelines.

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