Prevalence of Sudden Cardiac Death During Competitive Sports Activities in Minnesota High School Athletes

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Objectives. Reliable prevalence data would be useful in assessing the impact of sudden cardiac death in young competitive athletes on the community and designing effective preparticipation screening strategies.

Background. The frequency with which these catastrophes occur is largely unknown.

Methods. We utilized a circumstance unique to Minnesota in which the precise number of participants and deaths due to cardiovascular disease could be ascertained over a substantial period of time based on a long-standing insurance program for catastrophic injury or death, mandatory for all student athletes engaged in interscholastic sports.

Results. Over the 12-year period, 1985/1986 to 1996/1997, inclusive, three sudden deaths due to cardiovascular disease occurred in competitive high school athletes (grades 10–12) during competition or practice. At autopsy, 1 each proved to be due to anomalous origin of the left main coronary artery from the right sinus of Valsalva, congenital aortic valve stenosis (with bicuspid valve) and myocarditis. All three athletes were white and male, 16 or 17 years of age; two competed in cross-country/track and one in basketball.

During the study period there were 1,453,280 overall sports participations and 651,695 student athlete participants among the 27 high school sports. The calculated risk for sudden death was 1:500,000 participations and 1:217,400 participants per academic year (or 0.46/100,000, annually). Over a 3-year high school career for a student athlete the estimated risk was 1:72,500.

Conclusions. The risk of sudden cardiac death in a population of high school student athletes was small, in the range of one in 200,000 per year, and was higher in male athletes. The rare occurrence of sudden cardiac death in competitive sports underlines the limitations implicit in structuring productive and cost-effective broad-based preparticipation screening strategies for high school athletes.

(J Am Coll Cardiol 1998;32:1881–4)
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Sudden deaths on the athletic field occur most commonly in high school athletes and are due to a variety of underlying (and usually unsuspected) structural cardiovascular diseases (1–14). Although they are believed to be uncommon (1,3,4), the frequency with which such deaths occur remains largely unknown. Although reliable information regarding the prevalence of sudden cardiac death associated with competitive high school sporting activities would be useful in designing the most effective preparticipation screening strategies (15), such data have been very difficult to assemble. In the present study, we utilized the fortuitous circumstances in Minnesota, in which the number of high school participants and deaths due to cardiovascular disease could be ascertained over a substantial time period to establish reliable estimates for the frequency of these catastrophic events.

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Manuscript received February 27, 1998; revised manuscript received June 17, 1998, accepted August 6, 1998.

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adding the number of entries on all the team participation lists submitted to the MSHSL by the individual high schools; and

3. The average number of sports participated in by individual athletes over an academic year, calculated for 1996–1997, and used to indirectly estimate the number of individual student athlete participants from the number of sports participations for the overall study period.

Results

Sports participations. Over the 12-year study period, the total number of participations in all sports was 1,453,280. This number included 867,043 male (60%) and 586,237 female (40%) participations. Ages were 13 to 19 years (mean 16).

Cardiovascular-related deaths. There were three cardiovascular deaths during the study period (Table 1 and Figure 1); no other deaths occurred related to trauma or other sports-related causes. Each death occurred suddenly during exertion while the athlete was engaged in either organized competition (n = 2) or practice (n = 1). All three were male and white, 16 or 17 years of age; two competed in cross-country and track and one in basketball. None had a history of cardiac symptoms or a clinical cardiovascular evaluation. At autopsy, two deaths proved to be due to congenital heart disease, one each with anomalous left main coronary artery from the right (anterior) sinus of Valsalva (16,17) and aortic valvular stenosis with bicuspid valve, whereas the remaining athlete had an inflammatory mononuclear infiltrate in the left ventricular myocardium consistent with myocarditis. Each of these three athletes had standard preparticipation history and physical examination screening, which is customarily administered to all student athletes in Minnesota high schools, and these examinations had been regarded as negative for cardiovascular disease.

Frequency of sudden cardiac deaths. Based on sports participations. Taking into consideration the 1,453,280 sports participations and the three cardiovascular deaths, the calculated risk for sudden death was one death per 500,000 sports participations (0.20/100,000; 95% confidence interval [CI]: 0.04, 0.60). When this calculation was limited to male sports participations, the risk for sudden death was 1:289,014 (0.35/100,000; 95% CI 0.07, 1.0), or approximately 1:300,000 annually.

Based on sports participants. The average number of sports participated in by an individual student athlete during the 1996–1997 school year was 2.23. When this factor was used to estimate the number of individual participants (from the number of sports participations) for the study period, the calculated number was 651,695. Therefore, there had been three sudden deaths among these 651,695 student athletes, or one death per 217,400 individual participants per academic year (0.46/100,000; 95% CI: 0.09, 1.34), or approximately 1:200,000 annually.

When calculated specifically for the 388,810 estimated individual male athletes, the risk for sudden death was 1:129,870 (0.77/100,000; 95% CI: 0.16, 2.3), or about 1:130,000. For female athletes, the rate was zero (95% CI: 0, 1.1) per 100,000. Over the typical 3-year high school career of an individual athlete, the risk for sudden cardiovascular death was 1:72,500.

Discussion

Significance of sudden death in young athletes. The sudden and unexpected deaths of young competitive athletes due to unsuspected cardiovascular disease, which occur most often in high school sports (3,4), have achieved substantial visibility over the last several years (1). These catastrophic events have also stimulated considerable interest in the detection of cardiovascular abnormalities during life by preparticipation screening (15), as well as the appropriate criteria to be used for the disqualification of athletes with cardiovascular abnormalities from competitive sports (18).

Prior prevalence estimates. There remains, however, a paucity of credible data establishing the frequency with which these sudden deaths actually occur within young athletic populations. Such information is crucial from the standpoint of judging the impact of these catastrophic events on society (1) and in assessing the practicality of potential preparticipation screening strategies (15). Van Camp et al. (4), in a nationally

Table 1. Profiles of Sudden Cardiac Deaths in Minnesota High School Athletes

<table>
<thead>
<tr>
<th>No.</th>
<th>Age at Death (years)</th>
<th>Year of Death</th>
<th>Race/Gender</th>
<th>Sport</th>
<th>Circumstances of Collapse</th>
<th>Heart Weight (g)</th>
<th>Time of Day</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td>1990</td>
<td>W/M</td>
<td>Cross-country</td>
<td>During warm-up, stretching exercises</td>
<td>460</td>
<td>3 PM</td>
<td>Anomalous left main coronary artery</td>
</tr>
<tr>
<td>2</td>
<td>16</td>
<td>1993</td>
<td>W/M</td>
<td>Cross-country</td>
<td>Early during 5-K race</td>
<td>385</td>
<td>10 AM</td>
<td>Myocarditis</td>
</tr>
<tr>
<td>3</td>
<td>17</td>
<td>1996</td>
<td>W/M</td>
<td>Basketball</td>
<td>Minutes after entering game became fatigued; removed self from game; collapsed on bench</td>
<td>—</td>
<td>6 PM</td>
<td>Aortic valvular stenosis (bicuspid valve)</td>
</tr>
</tbody>
</table>

K = kilometer.
based survey, estimated the prevalence of sudden cardiovascular death to be 1:300,000 high school and college-aged athletes. However, the methodology employed in that study was largely dependent on news media accounts; therefore, it is possible that the number of deaths due to heart disease that were identified underestimated the true number of such deaths occurring in the United States during the time period analyzed (3,4).

**Minnesota prevalence estimates.** To establish reliable estimates for the frequency with which sudden death due to cardiovascular disease occurs in high school athletes, in the present study we took advantage of the circumstance in Minnesota, where there has been a long-standing and statewide obligatory catastrophic injury and death insurance plan that permitted definitive recognition of all the deaths of high school students engaged in competitive interscholastic sports programs. This indemnity program also permitted determination of the number of athlete participations in high school sports for each of the 12 years in the present study. In addition, the credibility of our data is substantiated by the fact that the Minnesota State High School League has consistently assembled participation and injury information with a high level of diligence and accuracy, aided by continuity in the employment of supervisory personnel over the period of study.

Consequently, the present investigation provides reasonable estimates for the frequency with which sudden death due to cardiovascular disease occurred in a high school athletic population and thereby establishes that these events are rare. We found the prevalence of sudden death to be about 1:200,000 individual participants per academic year and about 1:130,000 male athletes. The predominance of deaths in male athletes is consistent with the findings of prior surveys of athletic field deaths (2–5). When viewed in context of a typical 3-year interscholastic athletic career, we found the risk for sudden death to be only about 1:70,000; this latter figure approaches that previously reported for middle-aged and older trained and recreational runners dying primarily of coronary artery disease (19–21). Indeed, such relatively low overall risk associated with competitive athletics is reassuring and suggests that the high visibility provided these events, largely by the news media (1,22–26), is perhaps disproportionate to their impact on society in numerical terms.

**Implications for preparticipation screening.** There are certain inferences that can be made regarding standard preparticipation history and physical screening (15) based on the data presented here from our Minnesota athlete cohort. For example, our findings suggest that screening would have little impact on outcome (27). Only three deaths occurred in 12 years, and none of those particular athletes had been identified or suspected as having cardiovascular disease by virtue of screening. Moreover, in two of these three athletes (one each with a congenital coronary artery anomaly or myocarditis) we would not have expected standard screening to be successful in detection. On the other hand, in the third athlete with congenital aortic valvular stenosis, the preparticipation screening examination could well have raised suspicion of this lesion (by virtue of a loud heart murmur), as evidenced by the autopsy findings of bicuspid aortic valve, marked leaflet thickening and apparent restriction of valvular opening. The present study cannot, however, address the issue of how many student athlete participants were withdrawn from competitive sports because of the suspicion of cardiovascular disease raised during preparticipation screening at entry into high school.

Because our estimates for the risk of sudden death were derived from data obtained in a single state in which the majority of student athletes are white (95%) and ethnic and racial minorities are uncommon we are not absolutely certain that these findings can be extrapolated to all other regions of the United States. On the other hand, we have no particular reason to conclude that our Minnesota data are, for some reason, unrepresentative of other sports populations. Furthermore, it seems unlikely that similarly verifiable data can be collected effectively on a national scale due to several recognized obstacles to the retrieval of such information, such as confidentiality and legal issues, and most importantly, the multitude of problems encountered in assembling data from such a vast population. Certainly, the Minnesota prevalence data for sudden death reported here can potentially serve as a basis for comparison should findings of a similar nature become available from other regions of the United States or from other countries.

**References**

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