# Competing risks of mortality with marathons: retrospective analysis

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## ABSTRACT

**Objective** To determine from a societal perspective the risk of sudden cardiac death associated with running in an organised marathon compared with the risk of dying from a motor vehicle crash that might otherwise have taken place if the roads had not been closed.

**Design** Population based retrospective analysis with linked ecological comparisons of sudden death.

**Setting** Marathons with at least 1000 participants that had two decades of history and took place on public roads in the United States, 1975-2004.

**Main outcome measures** Sudden death attributed to cardiac causes or to motor vehicle trauma.

**Results** The marathons provided results for 3 292 268 runners on 750 separate days encompassing about 14 million hours of exercise. There were 26 sudden cardiac deaths observed, equivalent to a rate of 0.8 per 100 000 participants (95% confidence interval 0.5 to 1.1). Because of road closure, an estimated 46 motor vehicle fatalities were prevented, equivalent to a relative risk reduction of 35% (95% confidence interval 17% to 49%). The net reduction in sudden death during marathons amounted to a ratio of about 1.8 crash deaths saved for each case of sudden cardiac death observed (95% confidence interval: 0.7 to 3.8). The net reduction in total deaths could not be explained by re-routing traffic to other regions or days and was consistent across different parts of the country, decades of the century, seasons of the year, days of the week, degree of competition, and course difficulty.

**Conclusion** Organised marathons are not associated with an increase in sudden deaths from a societal perspective, contrary to anecdotal impressions fostered by news media.

## INTRODUCTION

Physicians often recommend the health benefits of exercise, and millions of people take part on a regular basis, yet the outcome for a few participants is sudden death. These fatalities are typically diagnosed as "sudden cardiac death" and research has found no ideal method for predicting such events.[1-3] The deaths attract repetitive media attention, such as the high publicity given to deaths that occur in marathon runners.[4-8]

In the United States, 42 643 individuals died in motor vehicle crashes over the 6 354 190 km of public roads during 2003 (equal to about 12 deaths per 26.2 miles (the length of a marathon) of road per 1000 hours).[9] These deaths occur more than a hundred times each day and tend to be under-reported in the media.[10 11]

No previous study has explored the extent to which marathons might actually decrease mortality. Our core theory was that the number of deaths attributed to running a marathon might be smaller than the number of deaths averted by the reductions in road crashes that would otherwise have occurred. To test this theory we examined marathons throughout the US for a population based test of whether the total number of sudden deaths changed when roads are closed to traffic and opened to marathon running.

## METHODS

*Marathon identification*—We screened the 328 marathons listed in the Runner's World registry on 1 January 2005. We randomly selected 26 marathons. We excluded marathons with fewer than 20 years of experience or

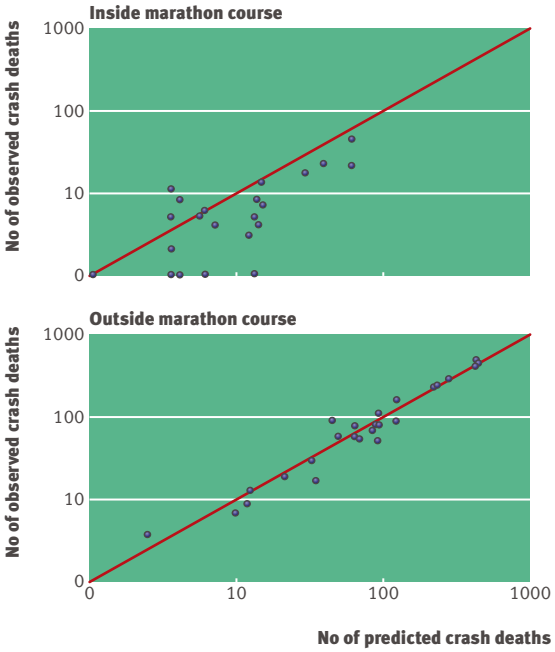


**Fig 1** | Comparison of observed crash fatalities on marathon days relative to predicted crash fatalities on control days. Top: counties inside marathon route; bottom: counties outside marathon route and data from corresponding hours of road closures. Each point represents one marathon site summed over all years. Note logarithmic scale and zero values plotted at 1

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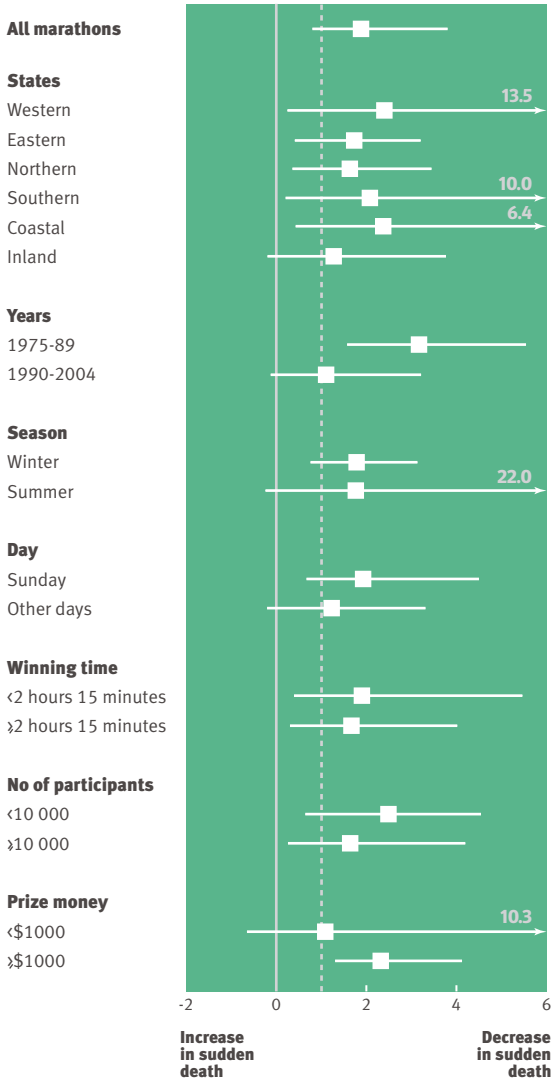


**Fig 2** | Ratio of crash fatalities prevented to cardiac deaths observed for average marathon. Values above zero indicate a decrease in crash deaths on marathon days relative to control days. Values over one indicate that number of crash deaths averted on marathon days exceeds number of cardiac deaths on marathon days. Full analysis appears at top based on all marathons and all times. 95% confidence interval calculated from bootstrap techniques. Weekday, winning time, number of participants, and prize money defined by most recent year

fewer than 1000 participants to ensure sufficient data for statistical testing of infrequent events. We obtained dates and routes for each specific marathon.

*Cardiac fatalities*—We obtained data on sudden cardiac deaths from local newspapers on the days after each marathon. Data on specific cause of death required up to four months of follow-up. Searches for missing data were validated by contact with race directors, local news media, or other sources.

*Crash fatalities*—We retrieved road safety information for the US from the National Highway Traffic Safety Administration. This provided population based data for all fatal crashes on public roads starting from 1975. We compared the number of observed fatal crashes during a marathon with the number expected based on the same day one week before and one week after. This technique controlled for season of the year, day of the week, and year of the century.

*National analyses*—The location of each marathon was characterised according to state counties. The time of each marathon was defined according to the approximate interval of road preparation, closure, clean up, and congestion. The size of each marathon was estimated from the number of finishers in each year and course.

*Statistical analysis*—Our primary analysis identified the number of motor vehicle deaths during each marathon compared with the number during the same hours one week before and one week after for the counties involving the marathon route. The same comparisons were then replicated for state counties that were outside the marathon route, and for the days immediately before and after each marathon to check for spillover in traffic flow.

## RESULTS

The 26 marathons over the 30 years provided results for 2250 separate days of observation (750 marathon days and 1500 control days). This amounted to 3 292 268 participants each running 42 km (26.2 miles). Over the 30 years there were 26 sudden cardiac deaths. Fifteen marathons had no deaths, six had one, and five had more than one. No major trend in cardiac deaths was observed over the years.

The typical participant with sudden cardiac death was a middle aged adult man (average age 41 years, 81% men). Autopsy results were available for 24, the most common finding being coronary atherosclerosis (n=21). Other contributing factors in scattered cases included electrolyte abnormalities (n=4), coronary anomalies (n=2), and heat stroke (n=1). The most common location of cardiac death was at or within 1.6 km (1 mile) of the finish line

The overall risk of sudden cardiac death was equal to 0.8 per 100 000 participants (95% confidence interval 0.5 to 1.1). This was equivalent to about three deaths per 42 km of roadway per 1000 hours. The risk of sudden cardiac death was equal to about two deaths per million hours of exercise.

A total of 12 364 motor vehicle fatalities occurred on the 750 marathon days and 1500 control days in the corresponding states. A minority (n=930) were in counties inside the course whereas most (n=11 434) were in counties outside the course. The typical person who died in a fatal crash was a middle aged adult man (mean age 38 years, 78% men).

A total of 85 individuals died in fatal crashes on the marathon days in counties inside the course during hours when roads were closed. In contrast, 262 individuals died in fatal crashes on the control days in the corresponding counties and hours. The discrepancy between observed and expected crash deaths on marathon days corresponded to a 35% relative decrease in risk (17% to 49%). This discrepancy was equal to an absolute decrease of 46 total crash deaths over the study ($P<0.001$).

We observed no major spillover in crash deaths to

## WHAT IS ALREADY KNOWN ON THIS TOPIC

Running a marathon can lead to sudden death, as documented 2500 years ago

Such fatalities at sporting events attract broad attention in modern media

## WHAT THIS STUDY ADDS

The absolute risk is much lower than estimated by small studies provoked by signal events

The relative risk is smaller than the risk of a motor vehicle fatality on the same roads during the same time intervals

The final 1.6 km of the marathon represents less than 5% of the total distance yet accounts for almost 50% of the sudden cardiac deaths

surrounding regions attributable to re-routing of traffic (fig 1). Secondary analyses also showed no spillover in crash deaths to days surrounding the marathon for the counties involved in the road closures. The ratio of crash deaths prevented was about 1.8 for each case of sudden cardiac death attributed to the marathon (95% confidence interval 0.7 to 3.8) (fig 2).

## DISCUSSION

In this study of more than three million marathon runners over 30 years the risk of sudden cardiac death was small, occurring at a frequency of 0.8 for every 100 000 participants. For each person who died from sudden cardiac death, we estimated a ratio of almost two lives saved from fatal crashes that would have otherwise occurred

### Societal perspective

Because we used a retrospective ecological design to study risk our study does not prove that individuals who die from running a marathon might have been saved from a motor vehicle crash. At the extreme, perhaps the reductions in crash deaths reflect the lives of spectators and uninvolved members of the community saved because of road closures. The observed ratio implies that participants in marathons may lower societal risk but may or may not decrease their personal risk.

### Individual psychology

Another limitation of our research is that we evaluated sudden death using numerical data whereas human psychology causes people to focus on some causes of death while neglecting others.[12] Cardiovascular deaths in athletes are shocking; moreover, identified lives are more salient than statistical lives, thereby slanting community consciousness away from motor vehicle crashes.

### Beyond marathons

Our research has other limitations. The data do not account for sudden cardiac deaths during training or after racing. The analysis excluded small marathons, yet the pattern suggested that marathons with fewer participants showed a somewhat higher protective association. Our study did not account for the potential enhanced health from regular exercise.[13]

### Clinical implications

Clinicians interested in preventing sudden cardiac death may be surprised by the low risk associated with marathon running. The rate we observed was about the same as the baseline hourly risk of death for a middle aged man.[14] Our results also imply that the screening that prevailed for the past 30 years yielded participants with a low absolute risk.[15 16]

### Policy relevance

The results highlight the ongoing frequency of road crashes and how brief changes in driving can lead to a measurable reduction in health losses. The distribution of cardiac deaths suggests that paramedic staffing for marathons should be planned on the basis of numbers of participants and that the last half of the marathon (and the last 1.6 km in particular) is the priority for resuscitation resources and ambulance preparedness.[17] The results also indicate that, for participants, the final sprint with sudden cessation may be more dangerous than generally realised.

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