All-cause mortality risks among participants in mass-participation sporting events

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ABSTRACT

Objectives Exercise transiently increases the risk for sudden death, whereas long-term exercise promotes longevity. This study assessed acute and intermediate-term mortality risks of participants in mass-participation sporting events.

Methods Data of participants in Dutch running, cycling and walking events were collected between 1995 and 2017. Survival status was obtained from the Dutch Population Register. A time-stratified, case-crossover design examined if deceased participants more frequently participated in mass-participation sporting events 0–7 days before death compared with the reference period (14–21 days before death). Mortality risks during follow-up were compared between participants and non-participants from the general population using Cox regression.

Results 546 876 participants (median (IQR) age 41 (31–50) years, 56% male, 72% runners) and 211 592 non-participants (41 (31–50) years, 67% male) were included. In total, 4625 participants died of which more participants had partaken in a sporting event 0–7 days before death (n=23) compared with the reference period (n=12), and the mortality risk associated with acute exercise was greater but did not reach statistical significance (OR 1.92; 95% CI 0.95 to 3.85). During 3.3 (1.1–7.4) years of follow-up, participants had a 30% lower risk of death (HR 0.70; 95% CI 0.67 to 0.74) compared with non-participants after adjustment for age and sex. Runners (HR 0.65; 95% CI 0.62 to 0.69) and cyclists (HR 0.70; 95% CI 0.64 to 0.77) had the best survival during follow-up followed by walkers (HR 0.88; 95% CI 0.80 to 0.94).

Conclusion Participating in mass-participation sporting events was associated with a non-significant increased odds (1.92) of mortality and a low absolute event rate (4.2/100 000 participants) within 7 days post-event, whereas a 30% lower risk of death was observed compared with non-participants during 3.3 years of follow-up. These results suggest that the health benefits of mass sporting event participation outweigh potential risks.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Acute exercise increases the risk for sudden death, whereas long-term exercise training promotes longevity.
⇒ Worldwide participation in mass-participation sporting events has increased rapidly in recent decades.

WHAT THIS STUDY ADDS

⇒ Participating in mass-participation sporting events was not associated with a significantly increased all-cause mortality risk within 7 days post-event, whereas the risk for all-cause mortality was significantly lower for participants compared with non-participants during 3.3 years of follow-up.
⇒ Participation in running and cycling events was associated with larger all-cause mortality risk reductions compared with participation in walking events.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The health benefits of participating in mass sporting events outweigh the potential risk of sudden death.
⇒ The association between type of sport and all-cause mortality risk reductions may be exercise intensity or fitness dependent, with greater benefits at higher exercise intensities.

INTRODUCTION

Regular physical activity is associated with a lower risk of cardiovascular diseases and mortality.[1–4] Nevertheless, exercise transiently increases the risk for sudden cardiac death (SCD) and sudden cardiac arrest (SCA) during and shortly after a bout of vigorous physical exertion.[5] Known risk factors for exercise-related SCD and SCA are older age,[6–8] male sex,[6 9] high exercise intensity,[10 11] low frequency of habitual vigorous exercise[12–15] and being a competitive athlete.[7] The annual incidence of exercise-related SCA in the European population is estimated at 0.19 per million in women and 2.63 per million in men with a survival rate of 59%.[16] The incidence of SCD is generally based on hospital and emergency medical services records, and/or media reports, and includes cases who died during or within 1 hour of exertion. This approach may underestimate the incidence of death triggered by exercise as participants in mass-participation sporting events could be admitted to the hospital with an out-of-hospital cardiac arrest due to an episode of exercise but died several days later.[17 18]

Worldwide participation in sporting events has increased rapidly in recent decades,[19 20] making exercise-related SCD and SCA more prevalent[21] and more likely to be highlighted in the media. To place the risks and benefits of exercise into perspective, we assessed the acute and intermediate-term mortality rates among participants in mass-participation sporting events. We compared these findings with mortality rates of the general

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population. We hypothesised that the acute exercise required by mass-participation sporting events would be associated with an increased risk of death in the participant, but that participants would have improved intermediate-term survival compared with the general population.

METHODS

Data source and study population

Data from Dutch participants in running (n=113), cycling (n=126) and walking (n=61) events between 1995 and 2017 were obtained from event organisations. Most mass-participation sporting events were organised during the weekend (92%). Participants were included if they: (1) were older than 18 years, (2) were living in the Netherlands according to the Dutch Population Register and (3) participated in at least one sporting event. Data for the control population (non-participants) were extracted from the Dutch Population Register and included individuals if they: (1) matched for birth date and sex with a participant and (2) did not participate in any of the selected sporting events. Habitual exercise activities were not considered in this definition, so it might be possible that the control population performed habitual exercise but did not participate in mass-participation sporting events. We received a matched control for a subset of the participants.

Participant data and outcomes

Age at participation, sex, sporting activity (running, cycling or walking) and event date were obtained from the event organisations. Race distance and race speed were available in 95% and 41% of the population, respectively. Only age and sex were available for the control population. Survival status and date of death were obtained from the Dutch Population Register.

Study design

We assessed acute risk with a time-stratified case-crossover design and intermediate-term risk with a cohort study design. Case-crossover designs have been used to evaluate the acute risks from transient exposures.[13 22] This design compares the same individual at different time points (figure 1A) instead of comparing different individuals at the same time. Participants of mass-participation events who died according to the Dutch Population Register were selected for the 'acute-risk' analysis. Their exposure to a mass-participation sporting event prior to their death, the 'risk' period, was compared with their exposure during the reference period. This provides self-matching for the deceased participants and helps eliminate confounding by factors that are constant within the participant over time. For the main analyses, the risk period was defined as sporting event participation at 0–7 days before death. The reference period was defined as 14–21 days before death. The 7-day period was based on the median length of hospital stay (6 days (IQR 2–15)) of individuals who had an out-of-hospital cardiac arrest in the Netherlands,[23] and the 2023 European Society of Cardiology guidelines recommending evaluation of the neurological prognosis no earlier than 72 hours after admission in all comatose survivors after cardiac arrest.[24] The reference period was selected to minimise bias due to trends in exposure, outcome risk and seasonal factors, and thereby to create a similar probability of the exposure and the risk of the outcome between the risk and reference periods.[22] For example, the risk and reference period included similar weekdays (eg, most mass-participation sporting events are organised in the weekend), and the reference period was placed before the risk period (eg, both periods before death). Sensitivity analyses

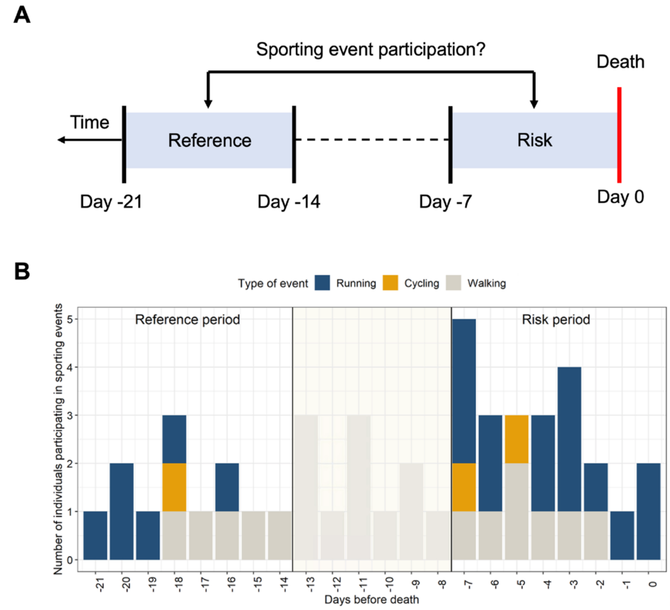

Figure 1 The study design of the time-stratified case-crossover (A) and number of individuals that participated in sporting events 3 weeks before death (B).

were performed using different durations of risk and reference periods. For the risk period, time intervals of 0–4, 0–9, 0–13 days before death were used. For the reference period, analyses were performed using a time interval of 1, 2 and 4 weeks before date of death, with a similar duration as the risk period.

The cohort design to determine intermediate-term mortality risk used the date of the last mass-participation sporting event (ie, most recent) as the start of follow-up (ie, baseline/origin). Hence, individuals with participations in multiple sporting events were only included once. The participant's entry date was used as the baseline date for the birthdate and sex matched non-participant. Non-participants who died before their baseline date were excluded. Participants and non-participants were followed to death or to their last survival status assessment (ie, end time).

Statistical analyses

Normally distributed data are presented as means (±SD), and non-normally distributed data as the median (IQR). For categorical data, the frequency with percentages was used. Differences between groups were tested using a one-way analysis of variance for normally distributed continuous data, the Kruskal-Wallis rank sum test for not normally distributed continuous data and the χ^2 test for categorical data.

The time-stratified case-crossover study used a conditional logistic regression model to estimate ORs and 95% CIs. The likelihood ratio test was used to estimate the p value. Exploratory analyses were performed for subgroups of age (<35 vs≥35 years), sex (male vs female), year of the event (<2008 vs ≥2008), type of event (running vs other sports) and the number of previous participations to mass sporting events (0–1 vs ≥2). As a low rate of participations in mass sporting events during the risk or reference period may induce bias to the estimated ORs, sensitivity analyses were performed using Bayesian statistics with different informative priors based on the literature[5 13 25 26] following a Laplace distribution with 5000 iterations.[27]

For the cohort study design, stratified Kaplan-Meier curves and log-rank tests were conducted to assess differences in

Table 1 Characteristics of the study population

Characteristics	Case-crossover study*				Cohort study†				
	Participants (n=4625)	Runners (n=2820, 61%)	Cyclists (n=608, 13%)	Walkers (n=1197, 26%)	Non-participants (n=211 592)	Participants (n=546 876)	Runners (n=394 981, 72%)	Cyclists (n=60 586, 11%)	Walkers (n=91 309, 17%)
Age at sporting event (years)	54 (45–63)	50 (42–57)	61 (51–68)	63 (56–70)	41 (31–50)	41 (31–50)	38 (29–47)	44 (33–54)	53 (44–61)
Sex (% male)	3430 (74%)	2137 (76%)	537 (88%)	756 (63%)	141 592 (67%)	304 190 (56%)	224 721 (57%)	49 123 (81%)	30 346 (33%)
No previous sporting events	2 (1–3)	2 (1–3)	1 (1–3)	2 (1–3)	NA	2 (1–3)	2 (1–3)	2 (1–3)	2 (1–4)
Race distance (km)‡	NA	15 (15–16) min 4; max 42	75 (45–145) min 10; max 245	18 (15–25) min 5; max 180	NA	NA	15 (12–6) min 1; max 42	110 (60–150) min 4; max 245	18 (15–21)min 5; max 180
Race distance categories (km)‡	NA	<10: 207 (7%) 10–20: 2128 (77%) 21–41: 387 (14%) ≥42: 60 (2%)	<80: 273 (51%) 80–119: 55 (10%) 120–159: 91 (17%) ≥160: 114 (21%)	<10: 58 (6%) 10–19: 417 (46%) 20–29: 365 (40%) ≥30: 73 (8%)	NA	NA	<10: 76 838 (20%) 10–20: 236 067 (60%) 21–41: 66 532 (17%) ≥42: 14 351 (3%)	<80: 14 935 (30%) 80–119: 11 196 (21%) 120–159: 11 081 (23%) ≥160: 11 930 (24%)	<10: 1551 (2%) 10–19: 40 463 (54%) 20–29: 26 959 (36%) ≥30: 6082 (8%)
Speed (km/hour)‡	NA	10.9 (9.9–12.1)	18.0 (15.8–22.1)	NA	NA	NA	10.6 (9.6–11.8)	20.2 (17.6–23.2)	NA

*All characteristics were statistically significant different between the runners, cyclists and walkers with p<0.001, except for the number of previous participations to sporting events with a p=0.003.
†All characteristics were statistically significant different between the non-participants and participants and between runners, cyclists and walkers with p<0.001, except for age between non-participants and participants (p=0.22).
‡Distance and speed were available in a subset of the population (95% and 41%, respectively).
NA, not applicable.

outcomes between participants and non-participants. Kaplan-Meier curves and log-rank tests were also stratified for age (<35 vs ≥35 years), sex (male vs female) and sporting event type (running vs cycling vs walking). Cox regression was used to calculate HRs with 95% CIs. The analyses were adjusted for age and sex, and for additional analyses the Cox regression was stratified for subgroups of age and sex. The proportional hazard assumptions were checked using the log-log survival plots and no violations were observed. All statistical analyses were performed in R V.4.1.1 using the packages matchit,[28] survival,[29] rstanarm[30] and survminer.[31] Values of p<0.05 were considered statistically significant.

Equity, diversity and inclusion statement

The study included the total available adult population of participants in mass sporting events living in the Netherlands. The mass-participation sporting events were organised throughout the whole country, and thus, the study population included participants with a broad range of gender, ethnic, racial, culture and socioeconomic backgrounds. Since the information about ethnic, racial, culture and socioeconomic backgrounds was not available for research purposes, it was not taken into account in the analyses. The research team included one woman (leading author) and four men (two researchers and two physician researchers). The author team includes two postdoctoral researchers and three senior academics from three different countries.

RESULTS

Study population

A total of 1 118 795 registrations for mass-participation sporting events were captured between 1995 and 2017, whereas data for 296 934 non-participants were obtained from the Dutch Population Register. A total of 546 876 participants and 211 592 non-participants were available for analyses after excluding duplicates and unmatched non-participants (online supplemental figure 1). The participants participated in 49 different mass sporting events. Running, cycling and walking events ranged in distance from 1 to 42, 4 to 245 and 5 to 180 km (online supplemental figure 2), respectively. The median age of the participants was 41 years (31–50) and the majority was male (56%, table 1). Participants mostly participated in running events (72%) with a median individual participation in 2 (1–3) previous events between 1995 and 2017. Median age was lowest in running events (38 years (29–47)). Cyclists had the highest proportion of males (81%). A total of 4625 participants died after a median follow-up of 3.8 years (1.6–7.3). Deceased participants were older (54 (45–63) years) and more often male (74%) compared with the total population of participants in mass sporting events. Deceased participants mostly participated in running events (61%). The non-participants (n=211 592) were of similar age (41 (31–50)) compared with the total participant population, but included a higher percentage of males (67% vs 56%, respectively), as not all participants had a matched control (online supplemental table 1).

Acute mortality risk

Twenty-three participants died within the risk period after a mass sporting event compared with 12 participants during the reference period (figure 1B), whereas 4590 participants died outside of the risk or reference periods. The odds of death were greater during the risk compared with the reference period (OR 1.92, 95% CI 0.95 to 3.85, table 2), but did not reach statistical

Table 2 Risk of exposure within risk and reference period among deceased participants

	Duration of risk period*	Duration of reference period	No. of participants in sporting events		OR (95% CI), p value
			Risk period	Reference period	
Main analyses	0 to −7 days	−14 to −21 days	23	12	1.92 (0.95 to 3.85), 0.06
Sensitivity analyses using different risk periods	0 to −4 days	−14 to −19 days	12	8	1.50 (0.61 to 3.67), 0.37
	0 to −9 days	−14 to −23 days	26	15	1.73 (0.92 to 3.27), 0.08
	0 to −13 days	−14 to −27 days	34	21	1.62 (0.94 to 2.79), 0.08
Sensitivity analyses using different risk and reference periods	0 to −7 days	−8 to −14 days	23	12	1.92 (0.95 to 3.85), 0.06
	0 to −7 days	−28 to −35 days	23	19	1.21 (0.66 to 2.24), 0.53
	0 to −4 days	−28 to −32 days	12	11	1.09 (0.47 to 2.51), 0.83
	0 to −9 days	−28 to −37 days	26	23	1.13 (0.64 to 1.99), 0.67
	0 to −13 days	−28 to −41 days	34	29	1.17 (0.71 to 1.93), 0.53

*Day 0 is date of death.

significance. Sensitivity analyses using risk periods of 0–4, 0–9, 0–13 days and reference periods of 1, 2 and 4 weeks before death did not change the results of the primary analyses (table 2). Bayesian statistics revealed similar non-significant ORs (online supplemental table 2). Exploratory analyses for subgroups based on age, sex, event year, event type and number of previous participations to mass sporting events demonstrated no differences in the risk of event participation (online supplemental figure 3). However, due to the low event rates, these subgroup analyses (especially in adults <35 years) might be underpowered and should be interpreted with caution. The cumulative 8-day incidence of death was 23 per 546 876 participants or 4.2 per 100 000 participants after event participation. Characteristics of deceased participants in the risk and reference period are summarised in online supplemental table 3.

Mortality during follow-up

During a median follow-up of 3.3 years (1.1–7.4), 4625 (0.8%) participants and 2494 (1.2%) non-participants died (figure 2). Participants had a 30% lower risk of death (HR 0.70, 95% CI 0.69 to 0.74) after adjustment for age and sex. The risk reduction

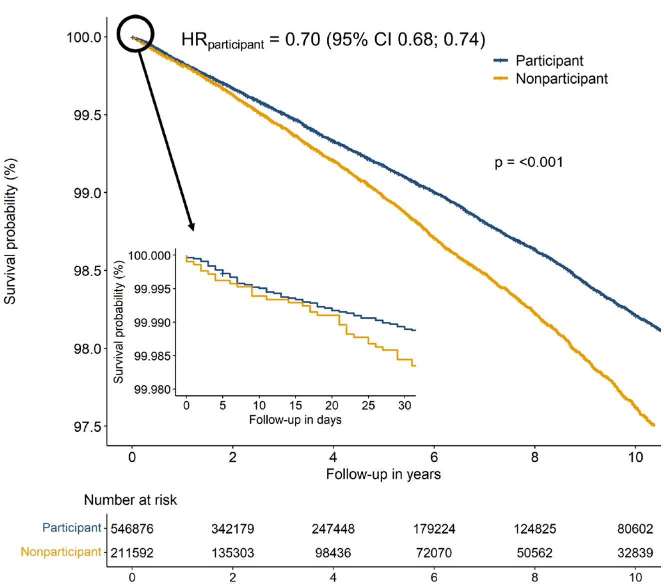

Figure 2 Unadjusted Kaplan-Meier curves for participants and non-participants with adjusted HRs and 95% CIs. The inner figure presents the survival including the first month after the sport event participation of the participants. HR with 95% CI was adjusted for age and sex.

for participants was present in males, females and older participants (figure 3, online supplemental figures 4 and 5). Participation in previous mass sporting events did not affect the risk reduction. However, sporting event type did affect the risk reductions. Participants in running events had the best survival compared with the non-participants, followed by participants of cycling and walking events (figure 3 and online supplemental figure 6). The risk reduction in runners (HR 0.65, 95% CI 0.62 to 0.69) and cyclists (HR 0.70, 95% CI 0.64 to 0.77) did not differ significantly, but the risk reduction of the walkers was significantly less (HR 0.88, 95% CI 0.81 to 0.94). Due to the large age difference between runners, cyclists and walkers, we performed stratified analyses for younger (<50 years) and older (≥50 years) individuals (online supplemental table 4). The stratified analyses showed similar findings. Longer race distances reduced the risk of mortality in runners and cyclists, but this association was less clear in walkers (figure 3).

DISCUSSION

This study investigated the risks of death in participants in mass-participation sporting events between 1995 and 2017. This study is unique because it assesses both the acute and intermediate-term risks of participation in a mass-participation sporting event (ie, running, cycling and walking) in a single cohort. Participating in mass sporting events was associated with a non-significant increased risk of death (OR 1.92). However, we observed a 30% lower risk of all-cause death compared with non-participants from the general population during 3.3 (1.1–7.4) years of follow-up. This risk reduction was present in different sport types and dependent on sport intensity as runners and cyclist had greater risk reductions than walkers. These findings suggest that the health benefits of mass sporting-event participation outweigh the potential risk of death triggered by exercise.

Acute mortality risk

This study revealed an incidence of death of 4.2 per 100 000 participants within 7 days following event participation. This rate is higher than previously reported rates between 0.3 and 2.1 SCDs per 100 000 participants.[5 25] Our higher values could be due to the duration of the risk period and outcome detection. We used a risk period of 8 days instead of the usual 1–24 hours postexercise. Shorter risk periods might overlook participants who died after becoming unwell and quit the event before the finish or who were admitted to the hospital and died soon but after 24 hours. We also used the national death registry instead of medical records and media releases to assess death, likely resulting in a more complete collection of deaths. Finally, our

Subgroup		N	N cases	OR [95% CI]
Age	Participants < 35 yrs	184,871	363	0.84 [0.70-1.01]
	Nonparticipants < 35 yrs	71,667	172	Reference
	Participants ≥ 35 yrs	362,005	4,262	0.68 [0.64-0.71]
	Nonparticipants ≥ 35 yrs	139,925	2,322	Reference
Sex	Female Participants	242,686	1,195	0.68 [0.61-0.75]
	Female Nonparticipants	70,000	579	Reference
	Male Participants	304,190	3,430	0.71 [0.67-0.75]
	Male Nonparticipants	141,592	1,925	Reference
No. previous sporting events	1	262,868	2,289	0.68 [0.64-0.72]
	2-4	187,750	1,612	0.71 [0.66-0.75]
	≥5	96,258	724	0.77 [0.71-0.84]
	Nonparticipants	211,592	2,494	Reference
Discipline	Running	394,981	2,820	0.65 [0.62; 0.69]
	Cycling	60,586	608	0.70 [0.64; 0.77]
	Walking	91,309	1,197	0.88 [0.81; 0.94]
	Nonparticipants	211,592	2,494	Reference
Race distance	Running <10 km	76,838	207	0.66 [0.57-0.76]
	Running 10-20 km	236,067	2,128	0.65 [0.61-0.67]
	Running 21-41 km	66,532	387	0.69 [0.62-0.77]
	Running ≥42 km	14,351	60	0.51 [0.39-0.66]
	Cycling <80 km	14,935	273	0.87 [0.76-0.99]
	Cycling 80-119 km	11,196	55	0.51 [0.39-0.67]
	Cycling 120-159 km	11,081	91	0.65 [0.53-0.81]
	Cycling ≥160 km	11,930	114	0.65 [0.54-0.78]
	Walking <10 km	1,551	58	1.21 [0.94-1.96]
	Walking 10-19 km	40,463	417	0.87 [0.78-0.97]
	Walking 20-29 km	26,959	365	0.88 [0.79-0.99]
	Walking ≥30 km	6,082	73	0.99 [0.78-1.24]
	Nonparticipants	211,592	2,494	Reference
Total	Participants	546,876	4,625	0.70 [0.67; 0.74]

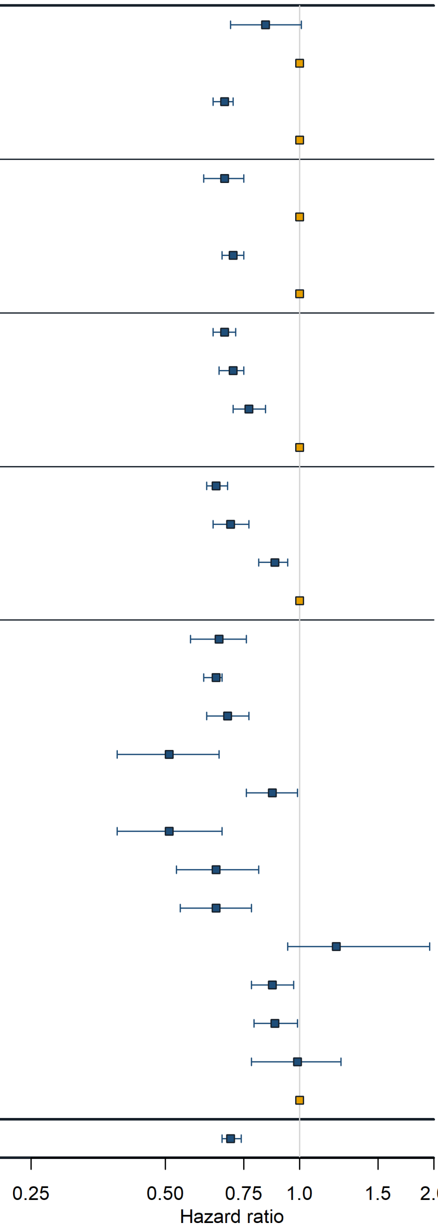

Figure 3 Forrest plot of survival during follow-up of participants compared with non-participants. HRs were adjusted for age and sex.

study used all-cause mortality instead of cardiovascular-related mortality, which may also contribute to the higher event rate.

The risk of death was not significantly increased between the risk and reference period, whereas the estimated OR of 1.92 (95% CI 0.95 to 3.85) was lower than reported in previous studies. A meta-analysis[15] estimated that an episode of moderate-to-vigorous physical activity increased the risk of SCD relative to rest with 4.98-fold (95% CI 1.47 to 16.91). Exercise-related SCD is lower in physically active individuals (relative risk: 11 (5–26) compared with sedentary individuals (relative risk: 74 (22–249)).[13] Our participants completed a median of 2 (1–3) previous mass sporting events, and exploratory analyses (online supplemental figure 3) did not demonstrate an impact of the number of mass-participation sporting events participations on the acute mortality risk. Hence, it is likely that they trained before their mass sporting event, which could partially explain the lower ORs. Furthermore, this study used all-cause mortality instead of SCD, which might have diluted the effect. Alternatively, most studies of exercise-related deaths compared the active period with inactivity or light exercise. We used as the reference period the 14–21 days before death. The victim's activity during that period is unknown, but likely included some exercise training before the event, and exercise-related events during this time would have reduced the difference between the risk and reference periods.

Mortality risk during follow-up

Participating in mass sporting events was associated with a statistically significant better survival (HR 0.70, 95% CI 0.69 to 0.74) compared with the control population. The beneficial effects of exercise and its effect size further reinforce findings from population studies that report a 20%–40% risk reduction of all-cause mortality depending on the physical activity volume.[1 2 32–34] Our study also suggested greater health benefits with higher exercise intensity, as evidenced by the largest risk reduction for runners (35%, metabolic equivalent of task (MET) ~10) and cyclists (30%, ~8 METs) and lower risk reductions for walkers (12%, ~4 METs).[35] We cannot determine whether this is due to the exercise mode or to individual characteristics of those participating in these activities. Nevertheless, the findings suggest that health benefits of exercise might also depend on intensity.[2 32 36] The strong risk reduction for all-cause mortality following participation in mass-participation sporting events suggests that the intermediate-term health benefits of exercise outweigh its acute risks.

Strengths and limitations

The strengths of this study are its large sample size, detailed information about the mass-participation sporting events and its evaluation of both acute and intermediate-term effects. The primary study limitation is the absence of information on the participants' health, atherosclerotic risk profile, habitual activity and lifestyle. For the case-crossover study, some potential important, but rare, time-varying confounders such as incidental smoking, an infection causing myocarditis, recreational drug use and environmental conditions (eg, high temperature, humidity) were not included. This could have produced residual confounding, but we limited this bias by comparing the same individual at different time points within a 3-week interval. It is also reasonable to assume that there is no change in the atherosclerotic risk profile between the risk and reference period (time difference: 0–24 days). For the benefits during follow-up, information on lifestyle, health status, other physical activity and adiposity was missing. Furthermore, there might be some built-in selection bias because the participants become more prominent (ie, survived) over time than the non-participants.[37] A second important limitation is that we do not have data on the cause and type of death due to the retrospective nature of the study and the inability to obtain consent from deceased individuals for additional data linkage. Cardiovascular disease accounted for the majority of sudden death in previous studies,[21] but we cannot exclude non-cardiac causes of death or deaths that were not related to the mass sporting event (eg, death due to a traffic accident). We also could not detect aborted SCAs. Finally, this study has an observational nature, so no causality can be derived from it.

CONCLUSION

Participating in mass-participation sporting events was associated with a non-significant increased risk of death (OR 1.92) during or shortly after the exercise bout (ie, 7 days postevent). More importantly, participants in running, cycling and walking events had a 30% lower risk of death during follow-up compared with non-participants from the general population. These findings suggest that the health benefits of participating in mass sporting events outweigh their potential risk of death.

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Contributors Concept and design: EAB, VA, D-CL, PDT and TMHE. Acquisition, analysis or interpretation of data: EAB and TMHE. Drafting of the manuscript: EAB. Statistical analysis: EAB. Critical revision of the manuscript for important intellectual content: EAB, VA, D-CL, PDT and TMHE. EAB and TMHE have full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. EAB and TMHE are the guarantors. The corresponding author (TMHE) attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and the study was approved by the medical ethical committee of the Radboud University Medical Center (#2016/2884). The study was exempted from informed consent according to the medical ethical committee of the Radboud University Medical.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. These third-party data are not freely available. These data cannot be shared publicly because of contractual restriction outlined by sport event organisers and the Dutch Population Register.

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