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Clinical paper

Exercise-related out-of-hospital cardiac arrest in Victoria, Australia

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Abstract

Background: Characteristics and outcomes of exercise-related out-of-hospital cardiac arrests (OHCA) are not well described in Australia.

Methods: This was a retrospective observational study of non-exercise-related aetiology and exercise-related OHCAs from the Victorian Ambulance Cardiac Arrest Registry between 2008 and 2016, including 12-month quality of life data from 2010 to 2016. Exercise-related OHCA was defined as taking place during or within 1 h of at least moderate intensity exercise. Descriptive statistics and adjusted logistic regression analyses were performed.

Results: During the study period there were 482 exercise-related and 33,358 non-exercise-related OHCAs. Jogging/running were the most frequent precipitating sports. The incidence rate of exercise-related OHCA was low (<1 per 100,000 person-years). Compared to non-exercise-related aetiology, exercise-related OHCAs were younger (mean 54 versus 70 years, $p < 0.001$) and more likely to present in an initial shockable rhythm (85% versus 18%, $p < 0.001$). Bystander CPR, and bystander or EMS defibrillation at any time, were more common among exercise-related arrests (93% versus 38%, $p < 0.001$ and 91% versus 24%, $p < 0.001$, respectively). A public access defibrillator was used in 24% of shockable exercise-related OHCAs compared with 4% of non-exercise-related OHCAs ($p < 0.001$). After adjustment for arrest characteristics, exercise-related OHCAs were more likely to survive to hospital discharge (50% versus 14%, $p < 0.001$; adjusted odds ratio [AOR] = 1.56, 95% confidence interval [CI] 1.25–1.96, $p < 0.001$) and survive to 12-months with good functional recovery (72% versus 62%, $p = 0.012$; AOR = 1.57, 95% CI 1.08–2.28, $p = 0.018$).

Conclusions: Exercise-related OHCAs were associated with better short- and long-term prognoses compared to non-exercise-related OHCAs. The underlying factors associated with this survival benefit warrant further investigation.

Keywords: Exercise, Sport, Out of hospital cardiac arrest, Epidemiology, Australia, Cardiac arrest registry

Introduction

Regular exercise is associated with numerous health benefits, including the reduction of cardiovascular disease risk.[1,2] Despite this, exercise can be a trigger of sudden cardiac arrest.[3] This is a health emergency linked with poor survival rates,[3] highlighted by high profile incidents, including deaths in soccer and cycling.[4,5] Such events generate significant media attention and scientific interest.[6]

Few studies have reported the characteristics and outcomes of exercise-related out-of-hospital cardiac arrests (OHCAs), and none to our knowledge in Australia. The incidence of exercise-related sudden cardiac arrest has been shown to be low, with a British study estimating the incidence to be 0.6 per 100,000 person-years.[7] Additionally, a recent Japanese study, reported that 0.3% of OHCAs

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occurred during exercise.[8] Reported survival rates vary internationally, ranging from 11% to 37%.[7–12]

Timely intervention, such as public access defibrillation, has been shown to improve survival in OHCA, including exercise-related OHCA; indeed, early defibrillation is recognised as a vital link in the chain of survival for cardiac arrest.[8,13] Further research is required however, to understand the characteristics of exercise-related OHCA patients and inform strategies to prevent or treat exercise-related OHCA. As such, this study describes the incidence, characteristics and outcomes of OHCAs occurring during, or within 1 h following, exercise in Victoria, Australia.

Methods

Study design and setting

This was a retrospective observational study of data extracted from the Victorian Ambulance Cardiac Arrest Registry (VACAR) between 1st January 2008 and 31st December 2016. Twelve-month health-related quality of life data was also available for patients arresting between 1st January 2010 and 31st December 2016. Traumatic OHCAs, drowning OHCAs, sports of low exercise intensity such as walking or snooker, and cases that occurred more than 1 h after exercise cessation were excluded.

Victoria, Australia, is a state with a population of approximately 6.4 million people, 75% of whom reside in the metropolitan region of Melbourne.[14] Ambulance Victoria is the sole provider of Emergency Medical Services (EMS) in the state. Protocols for OHCA treatment and resuscitation follow the Australian Resuscitation Council Guidelines.[15]

Data sources and definitions

Ambulance Victoria maintains the VACAR, which registers and collects clinical and outcome data for all OHCAs attended by EMS in the state, in accordance with Utstein recommendations.[16,17] For this study, we extracted all exercise-related OHCAs and all non-exercise-related OHCAs to enable comparison. The non-exercise-related group in this study includes presumed cardiac cases as defined by the Utstein template that recommends an arrest is presumed to be of cardiac aetiology unless its cause is obvious, such as trauma, drowning, drug overdose, or any other non-cardiac cause determined by rescuers. The non-exercise-related group also excludes exercise-related arrests.[17] To identify exercise-related OHCAs, we used a series of search terms to help identify OHCAs of at least moderate intensity. A working definition of “moderate intensity” exercise was used from the World Health Organisation (WHO) i.e. >4 metabolic equivalents, or an activity that expends four times the energy used by the body at rest.[18] We first manually reviewed all the case descriptions of OHCAs occurring at sporting facilities. For all cases occurring outside a sporting facility, the following terms were used to search the case descriptions documented by paramedics at the time of OHCA: “Running”, “jogging”, “marathon”, “football”, “soccer”, “athletics”, “rugby”, “swimming”, “gym”, “aerobics”, “tennis”, “golf”, “netball”, “basketball”, “martial arts”, “hockey”, “surfing”, “dancing”, “cycling”, “kayaking”, “canoeing”,” yoga”, “skiing”, “snow-boarding”, “exercise”, “workout”, “play”, “fitness”, “boot camp”, “iron man”, “hiking”, “softball”, “baseball”, “volleyball”, “bush walking”, “cricket”, “bowls”, “rowing”, “triathlon”, “badminton”, “karate”, “boxing”, “horse riding”, “bike riding”, “diving”, “kickboxing”, “lacrosse”, “polo”, “rock climbing”, “windsurfing” and their derivatives. This list of search terms encompasses the most popular sports participated in Australia.[19] All case descriptions from these searches were examined to determine whether they met the study inclusion criteria. We defined exercise-related OHCA as an OHCA that took place during or within 1 h of at least moderate intensity exercise.

For adult (>17 years) patients arresting since 2010, the VACAR assesses 12-month health-related quality of life and functional recovery. The telephone follow-up process has been described in detail previously.[20] To measure functional recovery, the Glasgow Outcome Scale-Extended (GOS-E) is used.[21] This tool provides a gauge of function on a scale of eight stages from death (GOS-E = 1) to upper good recovery (GOS-E = 8). The tool encompasses self-care, mobility, return to work, relationship and social and leisure behaviour. We defined a good GOS-E as a score of ≥7. To assess health-related quality of life post-arrest, the VACAR uses the Twelve-item Short Form Health Survey[22] (SF-12) and the EuroQol 5 Dimension (EQ-5D).[23] The SF-12 is not suitable for proxy response, and provides a mental component summary (MCS) and physical component summary (PCS) of health. It can also be used to derive the SF-6D. The mental and physical component scores range from zero to 100, while the SF-6D provides a single measure of health status and ranges from 0.3 to 1, where 1 represents full health. The EQ-5D evaluates five health domains, including mobility, activities, self-care, pain/discomfort and anxiety/depression. Responses are used to derive an index score, which is measured from −0.59 to 1, where 1 represents full health.

To calculate incidence rates of exercise-related OHCA, annual Victorian population estimates for each of the nine study years were sourced from the Australian Bureau of Statistics.[14]

Statistical analysis

Statistical calculations were performed on IBM SPSS software (version 24). Baseline descriptive statistics are presented as frequencies and proportions, median (interquartile range [IQR]), or mean (standard deviation [SD]), as appropriate. Categorical variables were compared with Chi-squared test or Fisher’s exact test as appropriate. Continuous variables were compared with t-tests or Mann-Whitney U test, as appropriate.

The primary outcome measure of this study was survival to hospital discharge. Good functional recovery (GOS-E ≥7) at 12 months post-arrest was also analysed as a secondary outcome in the subgroup of surviving patients for whom this outcome was available. We used multivariable logistic regression models to measure the association between arrest aetiology and both outcome measures, adjusting for known predictors of survival. The variables included in the multivariable models were aetiology (exercise-related/non-exercise-related), patient age (continuous), patient gender (male/female), public location (public location versus other e.g. private residence), rural location (yes/no), witness (bystander/EMS/not witnessed), bystander cardiopulmonary resuscitation (CPR) (yes/no), EMS response time (continuous), shockable rhythm (yes/no) and study year (continuous). For EMS witnessed OHCAs we entered the response time as zero minutes and indicated no bystander CPR. In addition, to compare the effect size of known predictors of survival according to arrest aetiology, we generated separate models for exercise-related and non-exercise-related OHCA using the same covariates as described above. Further, to assess the influence of public access defibrillation on survival, we generated a model including only unwitnessed or bystander witnessed exercise-related OHCA patients with an initial shockable rhythm, and adjusted for the same covariates described above. Results are presented as odds ratios (OR) and 95% confidence intervals (CI). A p value of <0.05 was deemed statistically significant.

Ethical approval

VACAR is categorised as a quality assurance project by the Victorian Department of Health Human Research Ethics Committee. The ethics committees of hospitals who receive cardiac arrest patients by ambulance also approved the collection of outcome data by the VACAR. This study was approved by the Research Committee of Ambulance Victoria and Austin Health Research Ethics Committee (HREC Reference Number: LNR/17/Austin/409).

Results

Characteristics

During the study period, 482 cases were identified as being exercise-related and 33,358 cases were of non-exercise-related aetiology. The average annual incidence of exercise-related OHCA was 0.94 per 100,000 person-years. This was less than the average annual incidence of non-exercise-related OHCA, which was 64.62 per 100,000 person-years. Among the exercise-related OHCAs, 474 (98%) were presumed to be of cardiac origin, five (1%) were presumed to be respiratory in nature, two were neurological and one was presumed anaphylaxis. Characteristics of exercise-related and non-exercise-related OHCA patients are presented in Table 1. Patients with exercise-related OHCA were younger and more often male ($p < 0.001$ for both). Exercise-related arrests were also more likely to occur in public places, be witnessed, and receive bystander CPR ($p < 0.001$ for all comparisons). Additionally, the vast majority of exercise-related OHCAs presented to EMS with an initial shockable rhythm and received an attempted resuscitation by EMS ($p < 0.001$ for both). A public access defibrillator was used in 24% of shockable exercise-related OHCAs compared with 4% of non-exercise-related OHCAs ($p < 0.001$).

Running or jogging, followed by golf, were the most common precipitating sports for exercise-related OHCA (Fig. 1). Individual sports (golf, running or jogging and gym) were the most common (39%), and pilates, horse riding, bowls, boxing and skateboarding were the least common (1%). The mean age of running or jogging related OHCAs was 49.0 years (SD 13.7), whereas the mean age of golf-related OHCAs was 69.1 years (SD 10.8).

Table 1 – Characteristics of exercise-related and non-exercise-related OHCA patients.

	Exercise-related OHCA	Non-exercise-related OHCA	*p* Value
Total cases, *n*	482	33,358	
Age (mean ± SD)	55.1 (±16.4)	69.5 (±17.2)	*p* < 0.001
Missing, *n* (%)	1 (0.2)	110 (0.3)	
Male gender, *n* (%)	441 (91.5)	21,385 (64.1)	*p* < 0.001
Missing, *n* (%)	0 (0)	17 (0.1)	
Location of arrest, *n* (%)			*p* < 0.001
Recreation/sporting complex	227 (47.1)	210 (0.6)	
Other public place	166 (34.4)	2916 (8.7)	
Private residence	63 (13.1)	25,748 (77.2)	
School	9 (1.9)	18 (0.1)	
Other	17 (3.5)	4466 (13.4)	
Metropolitan location, *n* (%)	363 (75.6)	23,105 (69.3)	*p* = 0.004
Missing, *n* (%)	2 (0.4)	134 (0.0)	
Witness, *n* (%)			*p* < 0.001
Public witnessed	381 (79.1)	9220 (27.8)	
EMS witnessed	49 (10.2)	2591 (7.8)	
Unwitnessed	52 (10.8)	21,330 (64.4)	
Missing, *n* (%)	0 (0)	217 (0.7)	
Bystander CPR[a],*n* (%)	401 (92.6)	11,582 (37.9)	*p* < 0.001
Initial rhythm, *n* (%)			*p* < 0.001
VF/pulseless VT	406 (84.6)	5925 (17.9)	
Asystole	39 (8.1)	23,386 (70.5)	
PEA	34 (7.1)	3817 (11.5)	
Unspecified non-shockable	1 (0.2)	56 (0.2)	
Missing, *n* (%)	2 (0.4)	174 (0.5)	
Cases defibrillated, *n* (%)	437 (90.7)	7841 (23.5)	*p* < 0.001
First shock (if defibrillated), *n* (%)			*p* < 0.001
Ambulance Victoria	300 (68.7)	7070 (90.2)	
First responder	33 (7.6)	443 (5.7)	
PAD	104 (23.8)	328 (4.2)	
Time to first EMS response[a], median (IQR)	8.3 (6.6–11.3)	8.2 (6.3–12.0)	*p* = 0.7

[a] Excludes EMS witnessed arrests. Proportions exclude missing data. Abbreviations: SD, standard deviation; OHCA, out-of-hospital cardiac arrest; EMS, emergency medical services; VF, ventricular fibrillation; VT, ventricular tachycardia; PEA, pulseless electrical activity; PAD, public access defibrillation and IQR, interquartile range.

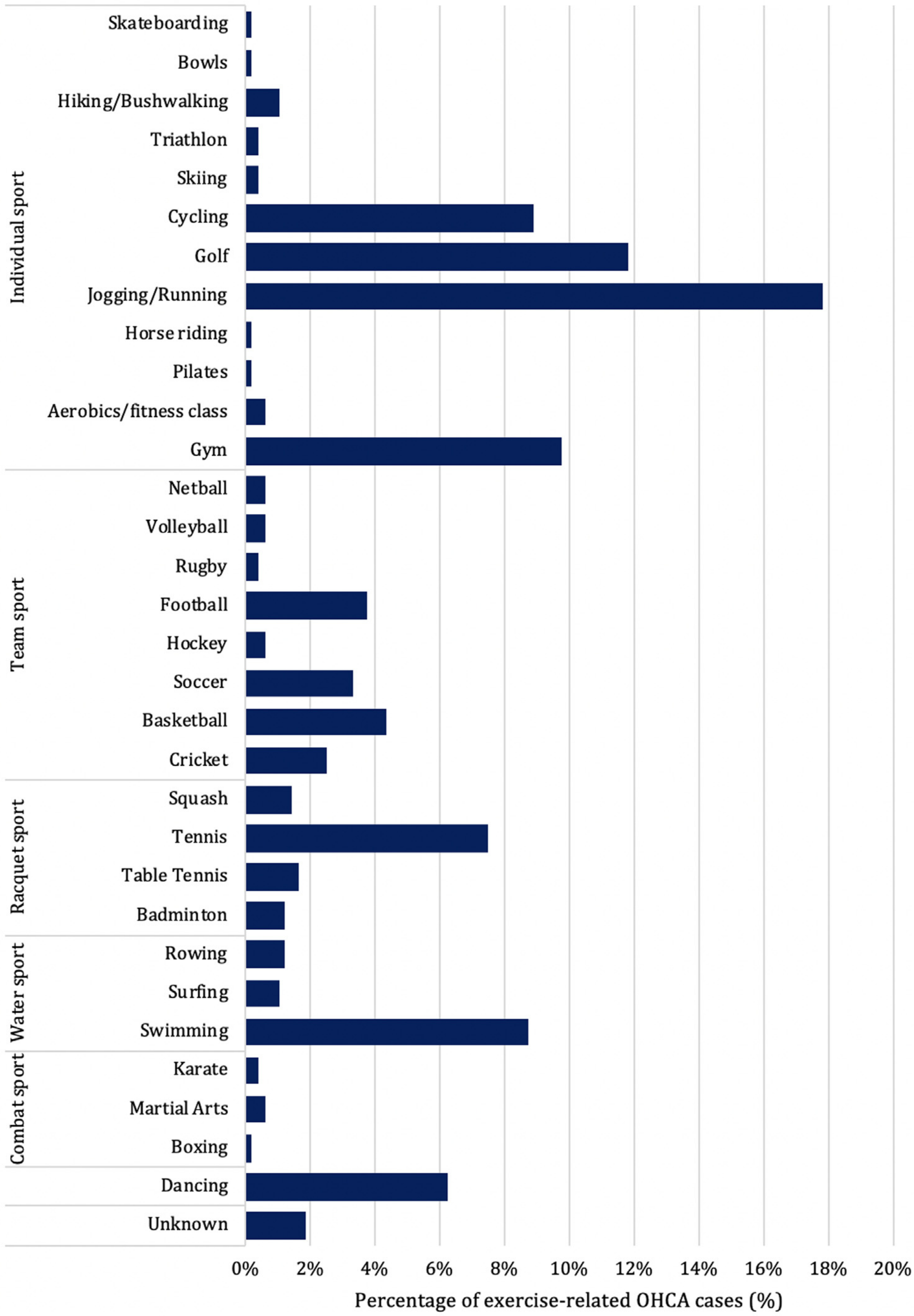

Fig. 1 – Sport distribution of patients with exercise-related OHCA.

Unadjusted survival outcomes

Table 2 describes the survival outcomes of exercise-related and non-exercise-related OHCA patients. Exercise-related OHCA patients were more likely to survive to hospital (66% vs. 33%, $p < 0.001$), and hospital discharge (49% vs. 14%, $p < 0.001$) than those with a non-exercise-related aetiology.

Among exercise-related OHCA patients whose initial rhythm was shockable, initial Public Access Defibrillation (PAD) by bystanders was not associated with a significantly higher proportion of survivors when compared with patients who were initially defibrillated by EMS (Table S1, 58% vs. 52%, $p = 0.4$).

Among survivors to hospital discharge, survival at 12 months was significantly higher for exercise-related OHCAs (Table 3, 99% vs. 93%, $p = 0.002$). There were a similar proportion of responders to 12-month follow-up in the exercise-related and non-exercise-related OHCA groups (87% vs. 84%, $p = 0.16$). The proportion of patients with a good functional recovery according to the GOS-E was significantly higher in exercise-related compared to non-exercise-related OHCA patients (72% vs. 62%, $p = 0.012$). Favourable outcomes were also

Table 2 – Survival outcomes of exercise-related and non-exercise-related OHCA patients.

	Exercise-related OHCA	Non-exercise-related OHCA	*p* Value
Attempted Resuscitation, *n*	474	16171	
ROSC at any time, *n* (%)	342 (72.2)	6603 (40.8)	*p* < 0.001
Survival to hospital, *n* (%)	314 (66.2)	5408 (33.4)	
Missing	0 (0)	12 (0.1)	*p* < 0.001
Survival to hospital discharge, *n* (%)	233 (49.2)	2311 (14.3)	
Missing	8 (1.7)	124 (0.1)	*p* < 0.001

Proportions exclude missing data. Abbreviations: N indicates number; OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation.

Table 3 – 12-month follow-up outcomes of adult exercise-related and non-exercise-related OHCA patients (2010-2016).

	Exercise-related OHCA	Non-exercise-related OHCA	*p* Value
Alive at 12 months, *n* (% of adults discharged alive)	191/193 (99.0)	1733/1861 (93.1)	*p* = 0.002
12-month follow-up completed, *n* (% of alive at 12 months)			*p* = 0.16
Responder	167 (87.4)	1447 (83.5)	
Non-responder	24 (12.6)	286 (16.5)	
Responder type, n (% of responders)			*p* = 0.007
Patient	147 (88.0)	1144 (79.2)	
Proxy	20 (12.0)	300 (20.8)	
Good GOS-E, *n* (% of responders at 12-months)	120 (72.3)	897 (62.4)	*p* = 0.012
Missing	1 (0.6)	10 (0.7)	
SF-6D score, median (IQR)[a]	0.86 (0.80–0.92)	0.86 (0.72–0.92)	*p* < 0.001
SF12 PCS score, mean, (SD)[a]	51.99 (7.72)	46.14 (10.87)	*p* < 0.001
SF12 MCS score, mean (SD)[a]	54.26 (7.53)	54.31 (8.57)	*p* = 0.9
EQ-5D index score, median (IQR)	1.0 (0.85–1)	0.85 (0.73–1)	*p* < 0.001

[a] Patient responders only. Proportions exclude missing data. Abbreviations: OHCA, out-of-hospital cardiac arrest; GOS-E, Glasgow outcome scale-extended; EQ-5D Index, EuroQol 5 Dimension Index; PCS, physical component summary; MCS, mental component summary; IQR, interquartile range; SD, standard deviation.

observed among exercise-related OCHA patients in the SF-12 PCS, SF-6D and EQ-5D ($p < 0.001$ for all). There was no significant difference between young (defined as age <35) and older persons (age ≥35) discharged alive (51% vs. 48%, $p = 0.91$) or with good GOS-E (75% vs. 71%, $p = 0.54$).

Adjusted associations with survival and 12-month functional recovery

Compared with arrests of non-exercise-related aetiology, patients with exercise-related arrests were 56% (95% CI 25–96%, $p < 0.001$) more likely to survive to hospital discharge after adjustment for confounders (Table 4). Fig. 2 compares the effect sizes of common predictors of survival between exercise-related and non-exercise-related OHCAs. A shockable initial cardiac arrest rhythm was the strongest predictor of survival for both aetiologies (exercise-related OR = 34.60, 95% CI 10.85–110.37; non-exercise-related OR = 13.64, 95% CI 11.86–15.68). Being EMS witnessed was also a strong predictor of survival among both cohorts (exercise-related OR = 7.48, 95% CI 1.70–32.96; non-exercise-related OR = 8.32, 95% CI 6.52–10.62), while bystander CPR was strongly associated with survival from exercise-related OHCA (OR = 2.85, 95% CI 1.17–6.97). Among exercise-related OHCA patients with an initial shockable rhythm, PAD was not associated with an increased odds of survival when compared with initial defibrillation by EMS (OR = 1.28, 95% CI 0.73–2.25).

Exercise-related arrests were also more likely to achieve a good functional recovery at 12 months, after adjustment for confounders (OR = 1.57, 95% CI 1.08–2.28, $p = 0.018$). The supplementary appendix compares factors associated with good GOS-E among exercise-related and non-exercise-related OHCA patients. Shorter EMS response time (per minute) (OR = 0.89, 95% CI 0.81-0.98) and bystander CPR (OR = 12.60, 95% CI 1.23–129.26) were the only statistically significant covariates associated with good functional recovery in exercise-related arrests. All but one exercise-related OHCA patient for whom GOS-E data was available presented to EMS with an initial shockable arrest rhythm, thus this variable was omitted from the model.

Discussion

To our knowledge, this is the first Australian study describing exercise-related OHCA, and the first internationally to report 12-month outcomes of these patients. We observed exercise-related OHCA patients to be more likely to survive to hospital discharge, be alive 12 months post-arrest, and have a good functional recovery when compared with patients with a non-exercise-related aetiology. Jogging or running and golf were the most frequent precipitating sports. Bystander CPR and an initial shockable arrest rhythm were strongly associated with survival following exercise-related OHCA.

Our results are comparable to previous research on exercise-related OHCA, which suggests that its incidence is low. For instance, the incidence rate in our study was similar to that observed in previous English and Scandinavian studies who reported rates of 0.6 per

Table 4 – Association of exercise-related aetiology on survival to hospital discharge and good 12-month functional recovery, adjusted for predictors of survival.

	Survival to hospital discharge	Good GOS-E (≥7)
Aetiology	OR (95% CI)	OR (95% CI)
Non-exercise-related	Reference	Reference
Exercise-related	1.56 (1.25–1.96)*	1.57 (1.08–2.28)*
Age (per year)	0.97 (0.97– 0.98)*	1.00 (0.997–1.01)
Male gender	1.06 (0.93–1.20)	1.67 (1.30–2.15)*
Witness		
Unwitnessed	Reference	Reference
Public witnessed	2.13 (1.83–2.49)*	1.17 (0.84–1.64)
EMS witnessed	8.18 (6.45–10.38)*	2.97 (1.82–4.85)*
Bystander CPR	1.39 (1.20–1.61)*	1.79 (1.28–2.51)*
VF/VT initial rhythm	13.91 (12.11–15.97)*	2.14 (1.57–2.93)*
Public location	1.77 (1.57–2.00)*	1.08 (0.85–1.37)
Year	1.02 (1.00–1.05)*	1.07 (1.01–1.12)*
Response time (per minute)	0.92 (0.91–0.94)*	1.01 (0.98–1.04)
Metropolitan Location (Greater Melbourne)	1.46 (1.29–1.65)*	0.93 (0.73–1.18)

Sample size of survival to hospital discharge regression: 16,209. Regression includes all patients with an attempted resuscitation. Sample size of Good GOS-E (≥7) regression: 1717. Regression includes all adult survivors to hospital discharge, excluding patients who were lost to follow-up.

Abbreviations: EMS, emergency medical services; CPR, cardiopulmonary resuscitation; VF, ventricular fibrillation; VT, ventricular tachycardia; GOS-E, Glasgow outcome scale-extended; OR, odds ratio; CI, confidence interval.

* Denotes $p < 0.05$.

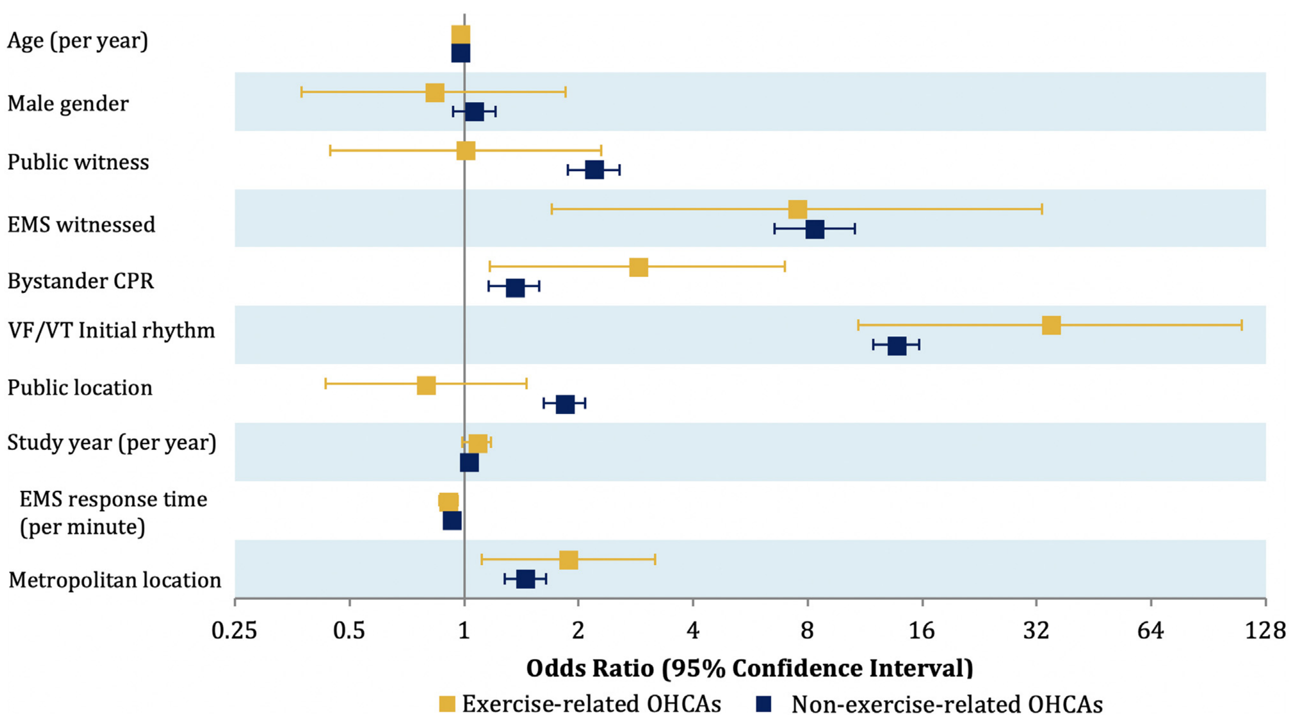

Fig. 2 – Comparison of independent predictors of survival to hospital discharge between exercise-related and non-exercise-related OHCA.

100,000 person-years and 2.1 per 100,000 person-years, respectively.[7,10] Our results also support previous studies which suggest that middle-aged males are most affected by exercise-related OHCA. In our study, the mean age of exercise-related arrests was 55.1 years and 91.5% were male. Such findings are analogous with the English and Scandinavian studies who reported mean ages of 58.8 and 50.9 years, respectively, and predominantly male populations.[7,10] It is plausible that increased atherosclerosis in the middle-aged to older populations may help to explain these findings.[24,25] However, previous work has attributed greater male participation in sport and greater levels of exertion in males to an increased incidence of arrest.[26] Despite this, females have a comparatively lower risk of OHCA and so a biological explanation for greater risk in males cannot be excluded.[27–29]

In contrast, we reported a higher proportion of exercise-related OHCAs presenting in a shockable rhythm than previous studies.[7,10] However, less than one third of these patients received defibrillation from a PAD. Although PAD among exercise-related OHCA patients was not associated with an increased odds of survival, our analysis may be limited by small sample size. A recent Japanese study found PAD considerably reduced the risk of death in exercise-related OHCA.[8]

The placement of PAD should therefore still be considered, particularly in recreation and sporting complexes. Currently, there is a programme in our setting that provides Victorian sporting clubs with the opportunity to acquire an AED for their club or sports facility.[30] A contractor employed by the Department of Health and Human Services provides successful applicants with an AED, basic training and six years of maintenance. Such initiatives promote PAD access, and encourage early defibrillation in exercise-related OHCA cases.

Exercise-related OHCA was associated with higher odds of survival to hospital discharge than non-exercise-related OHCA after adjusting for known predictors of survival, suggesting there are factors that remain poorly understood. Although we did not adjust our analyses for pre-existing health status of OHCA patients, it is possible that the survival benefit may also be related to the cardiovascular benefits of physical activity and increased arousal status of the sympathetic nervous system in exercise.[10] Some research also suggests exercise causes mild ischaemia, which protects the myocardium in infarction and arrhythmia.[31] Further investigation of the cardioprotective effects of exercise on OHCA is warranted.

Our study is the first to assess 12-month outcomes of exercise-related OHCA. There is little existing work looking at the long-term outcomes of exercise-related OHCA victims, with most similar studies only assessing survival to hospital discharge.[7,10] One Japanese study assessed 1-month survival and favourable neurological outcome (defined by cerebral performance category 1 or 2) in exercise-related OHCA.[8] Their data showed that exercise-related OHCA was associated with significantly improved outcomes at 1-month compared to non-exercise-related OHCA. Our 12-month outcome results support this study.

While exercise may trigger OHCA, there is no evidence to suggest the risks of physical activity outweigh the benefits. On the contrary, studies show the incidence of exertion-related acute myocardial infarction decreases with exercise.[32,33] Moreover, this study demonstrates favourable survival rates for exercise-related OHCA and there are many perceived cardiovascular benefits of exercising.[34] Exercise should form a fundamental component to cardiovascular health, however it is important to investigate and manage specific symptoms such as chest pain, palpitations and syncope during exercise.[35]

This is a retrospective study, which has some limitations. It is possible that some sports not encompassed in our search criteria were excluded. It is also not always possible for the rescuer of an OHCA to know that the patient was participating in sport, and whether this was within the 1-h time frame. Further, quality of life data only began routine collection in 2010 thus analyses are limited by small sample size, and data is only available at 12 months post-arrest. The VACAR does not routinely collect data around fitness levels, exact intensity of exercise and pre-existing cardiac conditions, which may be critical factors for sudden cardiac arrest in exercise. Down time (the time between collapse and initiation of any CPR) is also not available. Finally, we did not collect subsequent hospital treatment data, so we are unable to account for potential confounders such as hospital treatments in our analyses.

Conclusions

Whilst exercise-related OHCA incidence is low, these cases carry better short and long-term prognoses than non-exercise-related OHCA. The underlying factors associated with this survival benefit warrant further investigation. Given the large proportion of exercise-related OHCAs that occurred in sporting facilities and presented in a shockable rhythm, these facilities are likely to benefit from staff trained in CPR and defibrillation.

Conflict of interest statement

There are no conflicts of interest to declare.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.resuscitation.2019.03.043.

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