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Specific Activity Types at the Time of Event and Outcomes of Out-of-Hospital Cardiac Arrest: A Nationwide Observational Study

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This study aimed to describe the characteristics of out-of-hospital cardiac arrest (OHCA) according to specific activity types at the time of event and to determine the association between activities and outcomes according to activity type at the time of event occurrence of OHCA. A nationwide OHCA cohort database, compiled from January 2008 to December 2010 and consisting of hospital chart reviews and ambulance run sheet data, was used. Activity group was categorized as one of the following types: paid work activity (PWA), sports/leisure/education (SLE), routine life (RL), moving activity (MA), medical care (MC), other specific activity (OSA), and unknown activity. The main outcome was survival to discharge. Multivariate logistic analysis for outcomes was used adjusted for potential risk factors (reference = RL group). Of the 72,256 OHCAs, 44,537 cases were finally analyzed. The activities were RL (63.7%), PWA (3.1%), SLE (2.7%), MA (2.0%), MC (4.3%), OSA (2.2%), and unknown (21.9%). Survival to discharge rate for total patients was 3.5%. For survival to discharge, the adjusted odds ratios (95% confidence intervals) were 1.42 (1.06-1.90) in the SLE group and 1.62 (1.22-2.15) in PWA group compared with RL group. In conclusion, the SLE and PWA groups show higher survival to discharge rates than the routine life activity group.

Key Words: Heart Arrest; Resuscitation; Activity; Outcome

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is a global health concern with poor outcomes (1). To improve outcomes, strategies for planning, education and training and the response systems of emergency medical service (EMS) should be customized to specific patient groups. Resuscitation efforts and outcomes may be significantly different according to the activity at the time that an OHCA occurs. For example, patients who collapse during marathon running can be saved by immediate cardiopulmonary resuscitation (CPR) by bystanders and by rapid response on the part of EMS (2).

Sudden death in athletes occurs approximately once every 3 days in the United States. Each school or venue should have an emergency action plan that is coordinated with local EMS (3). The estimated annual incidence of cardiac arrest was 0.18 per 100,000 person-years among students and 4.51 per 100,000 person-years for school faculty and staff in one report (4). Another study reported that school-based automated external defibrillator (AED) programs resulted in high survival rates for both student athletes and older nonstudents with cardiac arrest on school grounds (5). Working is one of the most important activities of human beings and of economically active populations to earn money or to donate services, and many people dedicates much of their time to working. Adequate training in CPR and the use of an AED for workers are important components of workplace safety-training programs (6).

To improve the outcomes of OHCA occurring during specific activities, the activity related with the event of the OHCA should be investigated for its characteristics, and responsible persons should be encouraged to respond to the patients with customized strategy. Specific activities have more specific risk populations, characteristic bystanders, different accessibility to EMS and hospital care, and various outcomes. In particular, access to early bystander CPR, early defibrillation, and appropriate hospital care is critical. If we know the characteristics, we can pre-

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pare more customized action plans for each specific activity.

This study aimed to describe the characteristics of OHCA according to specific activity types at the time of event and to determine the association between specific activity types and outcomes according to activity type at the time of OHCA.

MATERIALS AND METHODS

Data source

We used a nationwide observational database of patients with confirmed OHCAs in the Republic of Korea. The database was a population-based emergency medical service (EMS)-assessed OHCA cohort. Cases were captured from ambulance run sheets on which OHCA was coded; data from January 2008 to December 2010 were used for this study. Ambulance run sheets were electronically stored in each headquarters of Provincial Fire Departments. Trained reviewers visited the study hospitals and reviewed the medical records to obtain information related to risks and outcomes according to demographics, time-related factor, Utstein risk factors, and hospital outcomes. All of the reviewers were formally trained and were provided with an operation manual to extract the data from the medical records correctly and to transcribe the data onto case report forms. When the reviewers could not determine information (for example, the initial electrocardiogram [ECG]), an emergency physician, who participated in the quality control of this study, reviewed and confirmed the case using faxed records or ECG sheets (7, 8). Information on specific activity was retrospectively captured from hospital medical record by trained reviewer. There was no test for reliability among reviewers. If there was no information in medical record, the case was categorized with unknown group.

Setting

In the Republic of Korea, population is approximately 50 million. Ambulance services are provided by 16 Provincial Fire Departments. Their highest service level is equivalent to the intermediate service level in the United States, which includes CPR, AED use, intravenous fluid resuscitation, and endotracheal intubation or laryngeal mask airway application under direct medical control. Most advanced cardiac life support using drugs is limited in EMS. Two or three emergency medical technicians (EMTs) ride along and give CPR in the field and during ambulance transport. The protocol does not allow EMTs to pronounce the death of patients or to transport patients to EDs without providing CPR (9).

Emergency departments are created by the national government based on the EMS Act. In the countryside, level 1 EDs (n = 16), level 2 EDs (n = 113), and level 3 EDs (n = 330) were designated in 2011. Of these, certified emergency physicians cover 24-hr and 365-day services in level 1 and 2 EDs. Level 3 EDs are usually served by general physicians.

Study population

The eligible patients were all OHCA patients with presumed cardiac etiologies confirmed by medical record reviews and having final outcomes on record during the study period. We excluded patients younger than 20 yr old and with non-cardiac etiologies (trauma, poisoning, asphyxia, hanging, drowning, and burn).

Risk factors

Major risk factors, such as sex, age, address, date and time, and place of the event, witnesses, bystander CPR, response time from call to arrival at the scene, and first ECG rhythm, were collected. The activities at the event were categorized on the basis of definition of World Health Organization and were re-categorized as routine life (RL), paid work activity (PWA), sports/leisure/education (SLE), moving activity (MA), medical care (MC), other specific activity (OSA), and unknown activity (Appendix 1). "OSA" included unpaid work, drinking, and other activities such as walking, wandering, running, stopping, creeping, sitting, religious acts, violent actions, and non-specific (10). These activities were collected from medical records made by physicians or discharge summary.

Outcome measurements

The primary end point was the proportion of subjects receiving bystander CPR and response time of EMS defined as the time interval from call to arrival at the scene. The secondary end points were survival to hospital discharge. The response time was re-categorized into early and delayed response groups according to cut-off values obtained from the medians.

Statistical analysis

We used the chi-square test for categorical variables and the independent t test for continuous variables. We compared the outcomes between the specific activity groups. We estimated the effect size of activity categories (SLE, PAW, MA, MC, OSA, and unknown group) compared with RL group for the outcomes.

Odds ratios (ORs) with 95% confidence intervals (95% CIs) using multivariate logistic regression models were calculated; ORs and 95% CIS were adjusted for potential risk factors regarding bystander CPR group and response time groups (sex, age, place, week, time, season, urbanization, and witnesses) and for survival to discharge (sex, age, place, week, time, season, urbanization, witnesses, bystander CPR, initial ECG, time from call to arrival at scene, EMS defibrillation, and ED level).

Ethics statement

The study was approved by the institutional review board at Seoul National University Hospital (H-1103-153-357). Informed consent was waived by the board.

RESULTS

Demographic findings

Of 72,256 patients with EMS-assessed OHCAs, 44,537 cases were finally analyzed, excluding subjects with unavailable medical records (n = 5,201), subjects with unknown outcomes (n = 2,900), subjects who were younger than 20 yr old (n = 2,288), and subjects with non-cardiac causes (n = 17,330). The survival to admission and discharge rates were 10.1% and 3.5%, respectively (Fig. 1).

Table 1 shows the demographic findings according to specific activity type. A total of 1,401 cases occurred during paid work, while most of the subjects collapsed during non-paid activities. The PWA group showed higher proportions of cases involving men, during summer, Monday to Wednesday, during daytime, in non-metropolitan areas, factory and commercial complexes, receiving EMS defibrillation, and with shockable rhythms than the RL group. The SLE group showed higher proportions in bystander CPR, male sex, younger age, occurrence in the spring, occurrence on Sunday and Saturday, occurrence during daytime, occurrence at leisure and commercial complexes, shockable rhythms, and EMS defibrillation than the RL group.

Overall bystander CPR was higher in the PWA group (6.1%) and in the SLE group (10.3%), while it was 1.2% in the MC group and 2.7% in the RL group. For ambulance response time (from call to arrival at scene), the intervals of the PWA and SLE groups were 9.0 ± 7.1 min and 11.6 ± 16.9 min, respectively, while the interval was 7.7 ± 5.5 min in the RL group. Finally, the outcomes by activity type showed wide variation. Survival to discharge was the highest in the SLE group (11.1% in overall SLE, 27.5% in sports only, and 8.9% in leisure only), followed by a rate of 8.2% in the PWA and 2.7% in the RL group (Table 2).

Main results

The adjusted ORs (95% CIs) for bystander CPR for each activity, compared with the RL group, were 1.93 (1.47-2.53) in the SLE group, 1.51 (1.13-2.03) in the PWA group, and 0.41 (0.21-0.79) in the MC group. The adjusted ORs (95% CI) for early response time were 0.83 (0.72-0.95) in the PWA group and 0.76 (0.66-0.88) in the SLE group, respectively. The MA group and OSA group showed no significant differences between them (Table 3).

For survival to discharge, the adjusted ORs (95% CI) were 1.62 (1.22-2.15) in the PWA group and 1.42 (1.06-1.90) in the SLE group. The MA and OSA group showed no significantly different outcomes, while the MC group showed better outcomes than the reference group (Table 3).

DISCUSSION

The most common activity in our study was routine life, followed by medical care, PWA, SLE, OSA, and MA group. Routine life included eating, drinking in home, putting on clothes, sleeping, intercourse, resting, washing, bathing, baby care, and family care (Appendix 1). The PWA and SLE groups showed similar characteristics, while the RL and MC groups shared similarities. Male sex was more common in the PWA and SLE groups, while it was less common in the RL and MC groups. The mean age was older in the RL and MC groups, while it was younger in the PWA and SLE groups.

Accessibility to resuscitation efforts and outcomes varied ac-

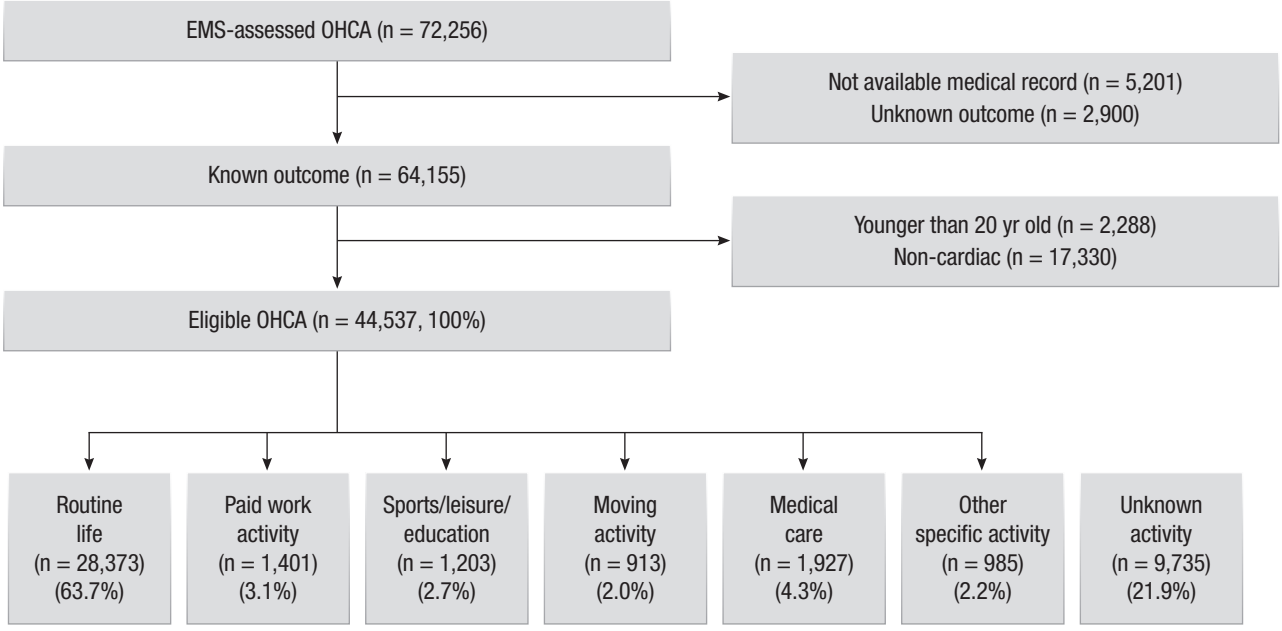

Fig. 1. Illustration of study population. EMS, Emergency medical service; OHCA, Out-of-hospital cardiac arrest.

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Table 1. Demographic findings of study participants by activity type

Factors	Total		Routine life		Paid work activity		Sports/leisure/ education		Moving activity		Medical care		Other specific activity		Unknown	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	44,537	100	28,373	100	1,401	100	1,203	100	913	100	1,927	100	985	100	9,735	100
Sex																
Male	28,066	63.0	17,221	60.7	1,174	83.8	1,021	84.9	635	69.6	1,190	61.8	651	66.1	6,174	63.4
Female	16,471	37.0	11,152	39.3	227	16.2	182	15.1	278	30.4	737	38.2	334	33.9	3,561	36.6
Age (yr)																
Mean, std	67.4	15.5	68.9	15.5	57.2	14.1	57.7	12.7	65.1	14.6	66.6	15.4	60.8	15.3	66.9	15.2
Season																
Spring (March to May)	11,282	25.3	7,124	25.1	370	26.4	348	28.9	216	23.7	475	24.6	260	26.4	2,489	25.6
Summer (June to August)	9,951	22.3	6,258	22.1	351	25.1	277	23.0	205	22.5	459	23.8	229	23.2	2,172	22.3
Fall (September to November)	11,131	25.1	7,149	25.2	334	23.8	312	25.9	238	26.1	457	23.7	235	23.9	2,406	24.7
Winter (December to February)	12,173	27.3	7,842	27.6	346	24.7	266	22.1	254	27.8	536	27.8	261	26.5	2,668	27.4
Week																
Sunday	6,763	15.2	4,439	15.6	130	9.3	264	21.9	129	14.1	254	13.2	170	17.3	1,377	14.1
Monday	6,702	15.0	4,222	14.9	220	15.7	142	11.8	125	13.7	358	18.6	141	14.3	1,494	15.3
Tuesday	6,181	13.9	3,862	13.6	197	14.1	155	12.9	134	14.7	278	14.4	141	14.3	1,414	14.5
Wednesday	6,084	13.7	3,843	13.5	246	17.6	128	10.6	133	14.6	269	14.0	114	11.6	1,351	13.9
Thursday	6,189	13.9	3,945	13.9	205	14.6	152	12.6	119	13	244	12.7	132	13.4	1,392	14.3
Friday	6,250	14.0	3,930	13.9	228	16.3	153	12.7	151	16.5	277	14.4	143	14.5	1,368	14.1
Saturday	6,368	14.3	4,132	14.6	175	12.5	209	17.4	122	13.4	247	12.8	144	14.6	1,339	13.8
Hour																
00 am-06 am	8,931	20.1	6,660	23.5	132	9.4	97	8.1	97	10.6	343	17.8	145	14.7	1,457	15.0
06 am-12 pm	14,442	32.4	8,974	31.6	618	44.1	415	34.5	329	36	682	35.4	290	29.4	3,134	32.2
12 pm-18 pm	12,484	28.0	7,114	25.1	515	36.8	477	39.7	333	36.5	564	29.3	314	31.9	3,167	32.5
18 pm-24 am	8,680	19.5	5,625	19.8	136	9.7	214	17.8	154	16.9	338	17.5	236	24	1,977	20.3
Urbanization																
Non-metropolitan	26,468	59.4	16,620	58.6	864	61.7	694	57.7	496	54.3	1,066	55.3	538	54.6	6,190	63.6
Metropolitan	18,069	40.6	11,753	41.4	537	38.3	509	42.3	417	45.7	861	44.7	447	45.4	3,545	36.4
Place																
Highway/street	695	1.5	45	0.2	63	4.5	36	3.0	285	31.2	4	0.2	19	1.9	207	2.1
Public offices and schools	199	0.4	36	0.1	30	2.1	55	4.6	8	0.9	2	0.1	12	1.2	56	0.6
Leisure complexes	374	0.8	18	0.1	12	0.9	266	22.1	1	0.1	1	0.1	15	1.5	61	0.6
Factory complexes	347	0.8	27	0.1	284	20.3	4	0.3	0	0	0	0.0	3	0.3	29	0.3
Commercial complexes	2,396	5.4	1,189	4.2	356	25.4	306	25.4	20	2.2	9	0.5	167	17	349	3.6
Public facilities	1,807	4.1	178	0.6	76	5.4	76	6.3	302	33.1	7	0.4	248	25.2	920	9.5
Home	30,264	68.0	24,249	85.5	101	7.2	55	4.6	178	19.5	40	2.1	308	31.3	5,333	54.8
Public residential complexes	1,968	4.4	1,757	6.2	11	0.8	4	0.3	4	0.4	26	1.3	4	0.4	162	1.7
Medical/nursing facilities	1,786	4.0	117	0.4	14	1.0	1	0.1	20	2.2	1,580	82.0	14	1.4	40	0.4
Farm	433	1.0	18	0.1	244	17.4	3	0.2	7	0.8	17	0.9	29	2.9	115	1.2
Unknown	4,304	9.7	739	2.6	210	15.0	397	33.0	88	9.6	241	12.5	166	16.9	2,463	25.3
Witness																
Yes	19,405	43.6	12,814	45.2	714	51.0	807	67.1	614	67.3	1,721	89.3	734	74.5	2,001	20.6
No	19,037	42.7	12,609	44.4	617	44.0	299	24.9	240	26.3	126	6.5	210	21.3	4,936	50.7
Unknown	6,095	13.7	2,950	10.4	70	5.0	97	8.1	59	6.5	80	4.2	41	4.2	2,798	28.7
EMS defibrillation																
Yes	1,934	4.3	1,016	3.6	151	10.8	173	14.4	74	8.1	133	6.9	113	11.5	274	2.8
No	7,892	17.7	4,475	15.8	460	32.8	366	30.4	309	33.8	420	21.8	335	34.0	1,527	15.7
Unknown	34,711	77.9	22,882	80.6	790	56.4	664	55.2	530	58.1	1,374	71.3	537	54.5	7,934	81.5
ECG, initial																
VF/pulseless VT	1,601	3.6	785	2.8	129	9.2	129	10.7	90	9.9	114	5.9	89	9.0	265	2.7
PEA	1,661	3.7	1,024	3.6	59	4.2	58	4.8	45	4.9	175	9.1	61	6.2	239	2.5
Asystole	32,960	74.0	21,990	77.5	862	61.5	720	59.9	523	57.3	1,103	57.2	583	59.2	7,179	73.7
Unknown	8,315	18.7	4,574	16.1	351	25.1	296	24.6	255	27.9	535	27.8	252	25.6	2,052	21.1
Level of ED																
Level 1	3,975	8.9	2,564	9.0	114	8.1	155	12.9	105	11.5	296	15.4	107	10.9	634	6.5
Level 2	18,919	42.5	12,250	43.2	634	45.3	583	48.5	450	49.3	994	51.6	491	49.8	3,517	36.1
Level 3	17,851	40.1	11,396	40.2	524	37.4	377	31.3	310	34.0	554	28.7	331	33.6	4,359	44.8
Level 4	3,792	8.5	2,163	7.6	129	9.2	88	7.3	48	5.3	83	4.3	56	5.7	1,225	12.6

CPR, cardiopulmonary resuscitation; EMS, emergency medical service; VF, ventricular fibrillation; VT, pulseless ventricular tachycardia; PEA, pulseless electrical activity; ED, emergency department.

Table 2. Resuscitation efforts and outcomes by activity type

Factors	Total		Routine life		Paid work activity		Sports/leisure/education		Moving activity		Medical care		Other specific activity		Unknown	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	44,537	100	28,373	100	1,401	100	1,203	100	913	100	1,927	100	985	100	9,735	100
Bystander CPR																
Yes	1,230	2.8	766	2.7	85	6.1	124	10.3	26	2.8	23	1.2	65	6.6	141	1.4
No	43,307	97.2	27,607	97.3	1,316	93.9	1,079	89.7	887	97.2	1,904	98.8	920	93.4	9,594	98.6
Time intervals, Mean, Std (min)																
From call to arrival to scene	8.0	6.4	7.7	5.5	9.0	7.1	11.6	16.9	7.7	8.1	7.5	5.2	7.7	4.9	8.1	6.3
Outcomes																
Survival to admission	4,499	10.1	2,562	9.0	227	16.2	231	19.2	163	17.9	518	26.9	195	19.8	603	6.2
Survival to discharge	1,570	3.5	761	2.7	115	8.2	134	11.1	63	6.9	231	12.0	86	8.7	180	1.8

CPR, cardiopulmonary resuscitation; ED, emergency department; SLE, sports/leisure/education; Std, standard deviation.

Table 3. The effect of activity type on the resuscitation efforts and outcomes of out-of-hospital cardiac arrest in the multivariate logistic regression analysis

Variables	Unadjusted			Adjusted		
	OR	95% CI		OR	95% CI	
Resuscitation efforts*						
Bystander CPR						
Routine Life	1.00			1.00		
Sports/leisure/education	4.14	3.39	5.06	1.93	1.47	2.53
Paid work activity	2.33	1.85	2.93	1.51	1.13	2.03
Moving activity	1.06	0.71	1.57	0.69	0.44	1.08
Medical care	0.44	0.29	0.66	0.41	0.21	0.79
Other specific activity	2.55	1.96	3.31	1.32	0.98	1.77
Unknown	0.53	0.44	0.64	0.60	0.49	0.73
Early response vs delayed response time†						
Routine Life	1.00			1.00		
Sports/leisure/education	0.82	0.73	0.92	0.76	0.66	0.88
Paid work activity	0.75	0.68	0.84	0.83	0.72	0.95
Moving activity	1.10	0.96	1.25	1.11	0.96	1.30
Medical care	1.08	0.98	1.18	0.96	0.80	1.15
Other specific activity	1.01	0.89	1.15	0.96	0.84	1.10
Unknown	0.92	0.87	0.96	1.00	0.94	1.05
Outcomes‡						
Survival to admission						
Routine Life	1.00			1.00		
Sports/leisure/education	2.39	2.06	2.78	0.91	0.74	1.13
Paid work activity	1.95	1.68	2.26	1.04	0.84	1.27
Moving activity	2.19	1.84	2.61	1.04	0.83	1.31
Medical care	3.70	3.32	4.13	2.09	1.62	2.69
Other specific activity	2.49	2.12	2.92	0.98	0.81	1.20
Unknown	0.67	0.61	0.73	0.77	0.69	0.86
Survival to discharge						
Routine Life	1.00			1.00		
Sports/leisure/education	4.55	3.75	5.52	1.42	1.06	1.90
Paid work activity	3.25	2.65	3.98	1.62	1.22	2.15
Moving activity	2.69	2.06	3.51	1.01	0.72	1.44
Medical care	4.94	4.23	5.77	1.63	1.12	2.37
Other specific activity	3.47	2.75	4.38	1.14	0.85	1.52
Unknown	0.68	0.58	0.81	0.78	0.64	0.95

*Adjusted for sex, age, place, week, time, season, urbanization, and witnesses. †Early and delayed response group were categorized by median value of response time (from call to arrival to the scene time). ‡Adjusted for sex, age, place, week, time, season, urbanization, witnesses, and bystander CPR, initial ECG, time from call to arrival scene, EMS defibrillation, and ED level. CPR, cardiopulmonary resuscitation; ED, emergency department; OR, adds ratio; 95% CI, 95% confidence interval.

cording to activity. The SLE and PWA groups had similar characteristics and similar associations with bystander CPR and with outcomes. We found a higher chance of receiving bystander CPR (adjusted OR = 1.51 in the SLE group and 1.93 in the PWA group) than in the RL group. However, the response times and prehospital times of the SLE and PWA groups were longer than in the RL group. The SLE and PWA groups showed significant better survival to discharge rates than the RL group in the adjusted model. From these findings, the chances of survival will be increased if early access to ambulance services and hospital care are provided for the SLE and PWA groups, because the patients in the SLE and PWA groups are younger and perhaps

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healthy enough to perform those activities. Our findings, significant variations of resuscitation efforts and outcomes, suggest that a priority for target population for CPR education, EMS deployment strategy, and hospital accessibility should be considered to achieve better outcomes. In particular, RL group showed major portion but lower CPR rate and low outcome. We should consider a specific intervention strategy for this group.

The mean response time in the SLE group was the longest among all activities. The total mean prehospital time was also much longer in the SLE group than in the PWA and RL groups. These results indicate that the accessibility to ambulances or to hospital services in the SLE group were relatively worse than in the RL group. Many sports and leisure complexes are far from downtown, where the ambulance stations and hospital EDs are located. Preparation for events is very important for SLE activity.

A prospective and comprehensive national survey on sports-related sudden cardiac deaths in France showed a high prevalence of witnessed cases (93%) and a relatively low bystander CPR rate (30.7%). Bystander CPR increases the chances of survival (odds ratio 3.73, 95% CI 2.19-6.39) (11). Sports-related sudden cardiac deaths are potentially preventable, which has fuelled an ongoing scientific debate on the merits and timeliness of pre-participation screening of competitive athletes (12). Our study found a very low bystander CPR rate (10.3%), although it was the highest among other activity groups. 67.1% of the patients was witnessed. Our data included sports, leisure, and educational activities, while above study subjects were only participating in sports with all age groups. It is difficult to compare the proportions directly. Previous studies have reported on sudden cardiac deaths in young athletes. However, according to the increase in the aging population, older people are more commonly enjoying themselves with sports, leisure, recreation, and education. This new trend in lifestyle has resulted in a large number of sports/leisure/education-related OHCAs (2.7%).

Workplace has been regarded as one of the most important public sites for the potential prevention of deaths from OHCAs, although there have been few studies on work-related OHCAs (13, 14). From a small retrospective study, workplace was not associated with better outcomes (13). These authors compared inside-workplace to outside-workplace OHCAs for demographics and Utstein factors. There were no significant differences in this small sample. The Occupational Safety and Health Administration of the United States reported that from 1991 to 1993, 15% of workplace deaths were due to sudden cardiac arrests (14). The American College of Occupational and Environmental Medicine (ACOEM) has supported the establishment of programs on the part of employers to use AEDs to manage sudden cardiac arrests in workplace settings. However, there have been few studies of work-related OHCAs. In this study, we found that 3.1% of the cases were paid work-related OHCAs, defined as the patient collapsing during the activity with economic benefit (10). In contrast to the SLE group, the PWA group showed a peak in daytime and weekday events, while the SLE group peaked in daytime events, during the weekend. Commercial and factory complexes were the most common sites for the PWA group (55.7%). The proportion of bystander CPR was 6.1%, and the response and prehospital times were not shorter than in the SLE group, but they were faster than in the RL group. In this study setting, public access defibrillator programs began in 2010, and therefore, there were no cases that received PAD shocks (15).

There is another important activity for the potential prevention of deaths due to OHCAs. Medical care facilities such as rehabilitation clinics, hemodialysis clinics, and general practice clinics, have high-risk populations, but they lack sufficient resources for resuscitation. Therefore, these facilities usually call EMS when there is an OHCA. We found that 4.3% of cases with OHCAs occurred while receiving medical care. Most of these patients collapsed in medical or nursing facilities (82.0%), 89.3% of the cases were witnessed, and the response time was relatively shorter, while the bystander CPR rate was very low (1.2%). Most of these patients might be long-term inpatients in medical and nursing facilities. Medical or nursing caregivers would not have initiated CPR because the patients had chronic and long-term disabilities but had no do-not-resuscitate (DNR) order card. In the Korea, DNR has not been culturally accepted for chronic patients. However, the survival to admission and discharge rates were very high.

Regarding medical care-related sudden cardiac deaths, chronic renal disease and hemodialysis were investigated. A retrospective cohort study reported on 363 patients who experienced a sudden cardiac death in the US outpatient dialysis clinics, of which 70.8% were witnessed (16). Another study reported that there were 4.5 sudden cardiac arrest events per 100,000 dialysis treatments during the 3-yr study period (17). The other study reported that the cardiac arrest rate was 400 of 5,744,708, corresponding to a rate of 7 per 100,000 hemodialysis sessions. Cardiac arrest was more frequent during Monday dialysis sessions than on other days of a week (18). However, our data cannot be classified among these specific medical care groups, so we cannot compare the incidence rates according to hemodialysis directly.

This study has several limitations. First, the main limitation of this study was that activity at the time of cardiac arrest was not known to be a major determinant of OHCA outcomes. Rather, other determinants like age of patients, presenting rhythm, whether witnessed, location of collapse, response time, bystander CPR, and defibrillation were different according to activity types and maybe linked with different outcomes. In particular, co-morbidities might be potential risks for outcome but were not available in many cases. Second, eligible OHCA patients with presumed cardiac etiologies and who were older than 20 yr old numbered 44,537. Of these, 21.9% had no information about their activities at the occurrence of the event. These huge un-

classified patients might be confounders. Third, retrospective medical record reviews had also limitations due to unclear information regarding bystander CPR rates. Fourth, we did not measure activity with a quantitative method. We classified activities according to WHO guidelines (10). Routine life can be divided into more precise activities, such as eating, playing, talking, and sleeping, using more quantitative measurement. Metabolic equivalent of task (MET) is a quantitative measurement example used to identify the physical activity load for real physical stress (18). Fifth, our study setting studied basic to intermediate EMS service levels, and hospital EDs provide advanced life support for OHCA victims. Therefore, the study results have limitations in being generalized to other EMS settings with advance prehospital care protocol. Finally, places and activities were not analyzed for their interaction for outcomes due to lack of detail information on places.

From a nationwide observational study, we found that the SLE and PWA groups had higher bystander CPR rates and longer response times to the scene than those in routine life activity. Survival to discharge was significantly higher in the SLE and PWA groups than in the RL group. We should consider and prepare more rapid access to bystander CPR and ambulance services for these specific activities.

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Appendix 1. Inclusion and exclusion criteria of activity during occurrence of out-of-hospital cardiac arrest

Category		Definition
1. Sports	Inclusive	A game with a goal of competition, such as golf, water skiing, swimming, horse riding, jogging, track, car racing, basketball, baseball, football, etc.
2. Recreation	Inclusive	Exercise without a goal of competition, such as playing, hobbies, recreation, climbing, watching movies, dancing, parties, group meetings, moving, walking, etc.
	Exclusive	Sports (1. Sports), driving for working (3. Paid work)
3. Paid work	Inclusive	Working to make money, job-related travel, job-related education, agriculture, physical working and mental working, job-related moving, employment as a driver (taxi, truck, transportation), professional cooking, professional athletics, babysitting
	Exclusive	Work without payment (4. Unpaid work)
4. Unpaid work	Inclusive	Helping with household work, preparing food, shopping for food, making furniture or curtains, working for family affairs, volunteer work at a hospital, church, job-related drinking, gardening, fishing, shooting, farming vegetables, baby care, family care without payment
5. Education	Inclusive	Participating in classes and lectures, competitive play with other schools, camping or tours with school
	Exclusive	Individual studying or teaching (3. Paid work or 4. Unpaid work)
6. Moving activity	Inclusive	Moving for exercise or sports during relaxation time, moving for recreation or school
	Exclusive	Employed driving or job-related moving (3. Paid work), shopping or volunteer work (4. Unpaid work), moving on a school bus (5. Education), traveling (2. Recreation), moving on an ambulance (8. Care)
7. Routine life	Inclusive	Eating, drinking, putting on clothes, sleeping, intercourse, resting, washing, bathing, baby care, family care
	Exclusive	Cooking, cleaning (4. Unpaid work), selling sex (3. Paid work)
8. Medical care	Inclusive	Hospitalized condition in a nursing home, undergoing dialysis, washed by a health professional, home nursing by nurse, transported on an ambulance, operation in a hospital, managed for another disease
9. Drinking	Exclusive	Drinking alcohol or suicide during drinking
10. Others	Inclusive	Walking, wandering, running, stopping, creeping, sitting, religious acts, violent actions, non-specific

This table was made on the basis of definition of World Health Organization. We categorized above activities with six activities as follows: 1) sports/recreation/education (SLE); 2) paid work activity (PWA); 3) routine life (RL); 4) moving activity (MA); 5) medical care (MC); and 6) other specific activity (OSA) (unpaid work, drinking, and other activities).