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Clinical paper

Basic life support for non-traumatic out-of-hospital cardiac arrests during school-supervised sports activities in children: A nationwide observational study in Japan

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Abstract

Objective: To investigate the prognostic impact of bystander-initiated cardiopulmonary resuscitation (CPR) and public-access automated external defibrillator (AED) use on non-traumatic out-of-hospital cardiac arrest (OHCA) occurring during school-supervised sports activities in children.

Methods: From a nationwide database of pediatric OHCAs occurring under school supervision in Japan, data between April 2008 and December 2020 were obtained. We analyzed non-traumatic OHCAs that occurred during school-supervised sports activities among schoolchildren from elementary, junior high, high, and technical colleges. A multivariable logistic regression model was used to evaluate the effect of basic life support (BLS) on 1-month survival with favorable neurological outcomes after OHCA.

Results: In total, 318 OHCA cases were analyzed. The 1-month survival with favorable neurological outcomes was 64.8% (164/253) in cases receiving both bystander-CPR and AED application, 40.7% (11/27) in cases receiving CPR only, 38.5% (5/13) in patients receiving AED application only, and 28.0% (7/25) in cases receiving no bystander intervention. Compared with cases receiving no BLS, cases receiving both CPR and AED had a significantly higher proportion of 1-month survival with favorable neurological outcomes (adjusted odds ratio [AOR]: 3.97, 95% confidence interval [CI]: 1.32–11.90, $p = 0.014$). However, compared to cases receiving no BLS, there was no significant difference in the outcome in the cases receiving CPR only (AOR: 1.35, 95% CI: 0.34–5.29, $p = 0.671$) and the cases receiving AED application only (AOR: 1.26, 95% CI: 0.25–6.38, $p = 0.778$).

Conclusion: The combination of CPR and AED as BLS performed by bystanders for non-traumatic OHCA during school-supervised sports activities improved the outcomes.

Keywords: Cardiopulmonary resuscitation, Automated external defibrillator, Out-of-hospital cardiac arrest, Schoolchildren, Sports

Introduction

Out-of-hospital cardiac arrest (OHCA) is a global public health concern and the leading causes of death.[1–3] OHCA among school-aged children is a rare[4–6] but devastating event that can result in significant societal losses and can affect the entire school community.[4,7]

Sports activities in schools are a common setting for pediatric OHCA.[8] Although sports activities can benefit children's health, they also carry an increased risk of cardiac events owing to physical exertion involved.[9,10] As schools are responsible for the safety of their students during these activities, it is imperative that appropriate measures are in place to manage cardiac events, including training in basic life support (BLS), that is bystander-initiated cardiopulmonary

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resuscitation (CPR) and the use of public-access automated external defibrillators (AEDs).[11,12]

Previous studies have shown that prompt implementation of BLS can improve outcomes for OHCA school-age children,[13–16] and recent systematic reviews have indicated that bystander interventions are significantly associated with survival after exercise-related OHCA.[17,18] However, the effectiveness of BLS in the specific setting of school-supervised sports activities for schoolchildren remains unclear. Therefore, determining the effectiveness of BLS in this setting is critical to ensure the safety and well-being of schoolchildren during sports activities.

We launched a nationwide observational study of pediatric OHCAs occurring under school supervision in Japan called Stop and Prevent cardIac aRrest, Injury, and Trauma in Schools (SPIRITS).[19] Using data from the SPIRITS study, we aimed to investigate the prognostic impact of BLS on non-traumatic OHCA occurring during school-supervised sports activities in schoolchildren.

Methods

Study design of SPIRITS

The rationale, design, and profile of SPIRITS have been previously described in detail.[19,20] In summary, SPIRITS is a nationwide observational study that utilizes a database combining two large-scale registries: the Injury and Accident Mutual Aid Benefit System of the Japan Sport Council (JSC) and the All-Japan Utstein Registry of the Fire and Disaster Management Agency (FDMA). The Injury and Accident Mutual Aid Benefit System provides benefits (medical expenses, disability compensation, or death compensation) in cases of injury, illness, disease, accident, or death to students and younger children under the supervision of schools or nurseries. It covers most students and younger children attending schools in Japan, encompassing approximately 16.3 million students and younger children, with data on approximately one million injury/accident cases reported and registered annually from schools and nurseries nationwide.[21] The All-Japan Utstein Registry is a population-based OHCA registry based on the international Utstein format[22] that covers approximately 127 million people in Japan. In this registry, cardiac arrest is defined as the cessation of cardiac mechanical activity, confirmed by the absence of signs of circulation. OHCA data are recorded by emergency medical service (EMS) personnel in cooperation with the physician in charge of the patient. Since prehospital termination of resuscitation by EMS personnel is generally not allowed in Japan, most OHCA patients treated by EMS personnel are transported to hospitals, and their data are recorded in this registry, except for OHCA patients who are not transported to a hospital by the EMS (i.e., transported to a hospital by family members/bystanders, non-EMS transporting vehicles, or by air ambulance). Thus, the SPIRITS database, developed by merging the two aforementioned nationwide registries, retains data on most pediatric OHCA cases occurring in school settings in Japan.

Study subjects

This study enrolled non-traumatic OHCA cases occurring during school-supervised sports activities from elementary school students (aged 6–12 years), junior high school students (aged 12–15 years), high school students (aged $\geq$ 15 years), and technical college students (aged $\geq$ 15 years) in Japan between April 1, 2008, and December 31, 2020. Patients in whom resuscitation by EMS personnel or bystanders was attempted and the first documented rhythm was recorded were included. OHCA cases due to traumatic causes (traffic accidents, falling incidents, and hanging) and those witnessed by EMS personnel were excluded from the analysis.

Data collection

We collected the following data from the SPIRITS database: initiation of bystander-CPR, application of public-access AED pads to the patient's chest, educational level, location of arrest, type of sports event, situations at the time of arrest, sex, origin of arrest, witness status of the arrest, first documented rhythm, dispatcher instruction of CPR, date and time of emergency call by bystanders, time of contact with the patient by EMS personnel, time of hospital arrival, shock delivery by public-access AED, and survival outcomes after OHCA.

Study groups

For this study, eligible OHCA cases were divided into four groups based on the presence or absence of BLS, which included the application of public-access AED pads to the patient's chest and the initiation of bystander-CPR. The four groups are: 'CPR+AED' (patient received AED and CPR), 'AED only' (patient received AED but not CPR), 'CPR only' (patient received CPR but not AED), and 'no CPR/AED' (patient did not receive any BLS).

Outcome measures

The primary outcome measure of this study was defined as 1-month survival with favorable neurological outcomes after OHCA. The neurological status of all OHCA survivors was evaluated by the physician in charge using the Glasgow-Pittsburgh Cerebral Performance Category (CPC) scale, which categorizes patients into five groups based on their functional status: category 1, good performance; category 2, moderate disability; category 3, severe cerebral disability; category 4, coma/vegetative state; and category 5, death/brain death. One-month survival with favorable neurological outcomes was defined as CPC 1 or 2.[23,24] The secondary endpoints included shock delivery by public-access AED, return of spontaneous circulation (ROSC) to the prehospital level and 1-month survival after OHCA.

Statistical analysis

Among eligible patients with OHCA, the change over time in the proportion of the types of BLS performed was assessed using the χ^2 test. Differences in patient characteristics and outcomes between groups were assessed using the χ^2 test or Fisher's exact test for categorical variables and analysis of variance for numerical variables. The proportions of prehospital ROSC, 1-month survival, and 1-month survival with favorable neurological outcomes were calculated by group. Univariate and multivariate logistic regression analyses were performed to assess the effect of BLS on 1-month survival with favorable neurological outcomes. In the multivariate analysis, odds ratios (ORs) and their associated 95% confidence intervals (CIs) were calculated after adjusting for potential confounders, including education level, location of arrest, type of sports event, situation at the time of arrest, sex, origin of arrest, witness status of arrest, dispatcher instruction of CPR, and time from emergency call to patient contact by EMS personnel. All tests were two-tailed, and a P-value of <0.05 was considered statistically significant. All statistical analyses were performed using SPSS v27.0J (IBM Corp., Armonk, NY, USA).

Ethics

The study adhered to the principles of the Declaration of Helsinki and the study protocol was approved by the ethics committees of Otsuma

Women's University (02-022) and Osaka University (22007). Personal identifiers were removed before data were provided, and individual informed consent was not required.

Results

Selection of study subjects

Fig. 1 shows a flowchart of the selection of eligible patients with OHCA for the analysis. During the study period, 642 OHCA cases were registered in the SPIRITS database, 451 of which were non-traumatic OHCAs that occurred under school supervision among elementary, junior high, high school, or technical college students. Of these, 318 (70.5%) occurred during sports activities, of which 40 were elementary school students, 106 junior high school students, and 172 high school/college students. Overall, most patients (79.6%, 253/318) received both public access AED application and bystander CPR, referred to as 'CPR+AED'. In contrast, 7.9% (25/318) of the patients did not receive BLS, referred to as 'no CPR/AED.

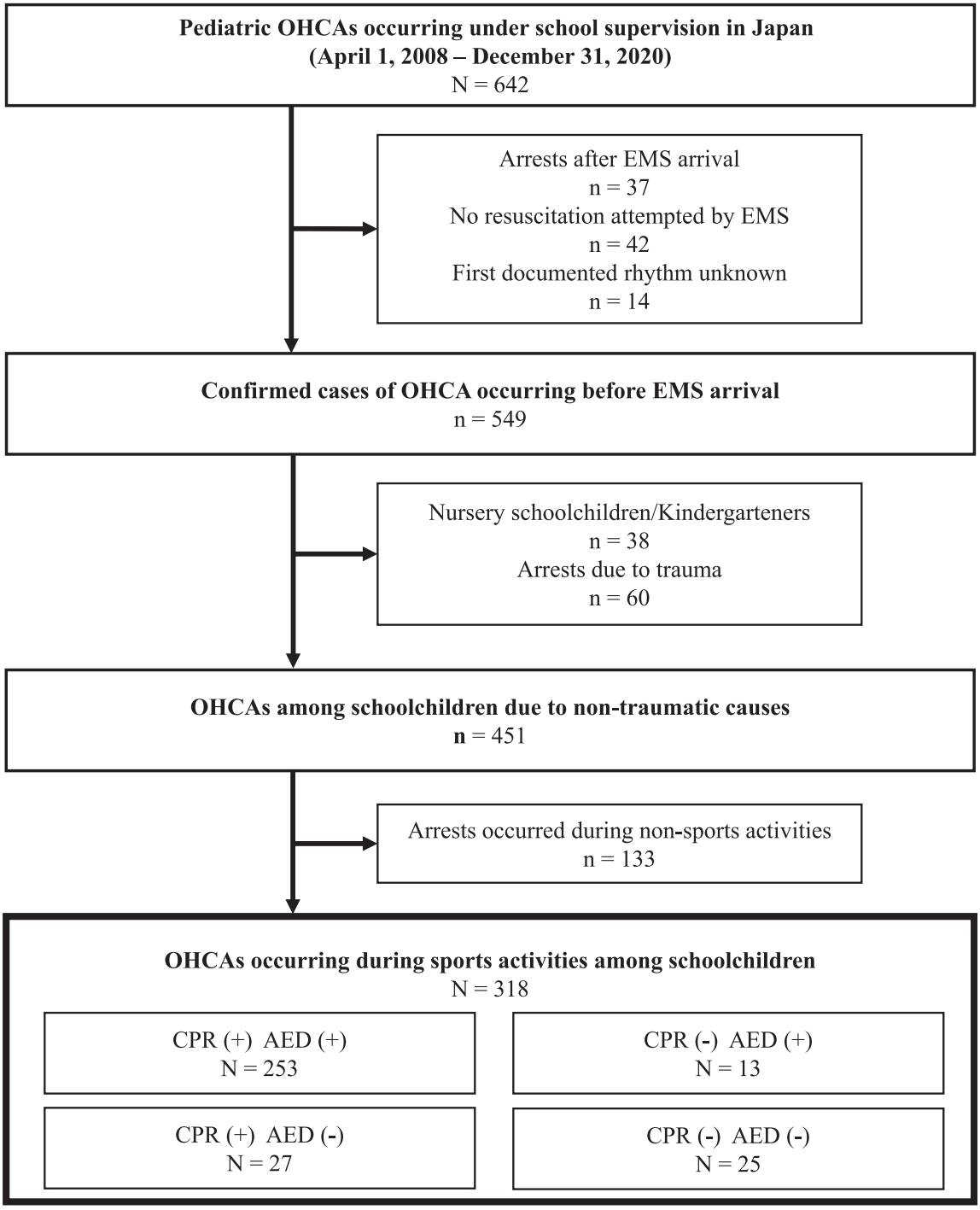

Fig. 1 – Flowchart for Selection of Eligible Patients with OHCA During School-Supervised Sports Activities in Japan.

Change over time in types of BLS performed on OHCA patients

Fig. 2 shows the changes in the proportion of BLS types performed on patients from 2008 to 2020. During the study period, the proportion of 'no CPR/AED' patients decreased from 11.8% in 2008–2010 to 5.5% in 2017–2020. The proportion of 'CPR+AED' patients increased from 65.8% in 2008–2010 to 89.0% in 2017–2020, whereas that of 'CPR only' patients decreased from 17.1% in 2008–2010 to 1.1% in 2017–2020.

Characteristics of study subjects

Table 1 shows patient characteristics based on the type of BLS they received. The proportion of patients receiving 'CPR+AED' was lower among female cases (65.6%, 40/61), arrests of non-cardiac origin (60.0%, 9/15), bystander-unwitnessed arrests (56.3%, 18/32), cases of ventricular fibrillation (VF) as the first documented rhythm (55.6%, 25/45), and cases without dispatcher instruction of CPR. However, there was no significant difference in the type of BLS received in terms of educational level, location of arrest, sports events, or situation at the time of arrest.

Outcomes after OHCA

Table 2 shows the outcomes of OHCA based on the type of bystander intervention. The proportion of patients with VF rhythm was relatively high when patients received any type of BLS compared to those without BLS: 90.1% in 'CPR+AED' patients, 81.5% in 'CPR only' patients, and 92.3% in 'AED only' patients. The 1-month survival with favorable neurological outcomes was significantly higher among 'CPR+AED' patients (64.8%, 164/253) compared to the other groups ('CPR only' 40.7%, 'AED only' 38.5%, and 'no CPR/AED' 28.0%).

Table 3 shows the factors associated with 1-month survival and favorable neurological outcomes after OHCA. In the multivariable analysis, the adjusted OR of 1-month survival with favorable neurological outcomes was approximately four times higher among 'CPR +AED' patients compared to 'no CPR/AED' patients (adjusted OR (AOR): 3.97, 95% CI: 1.32–11.90, $p = 0.014$), but was not significantly different from 'CPR only' patients (AOR:1.35, 95% CI: 0.34–5.29, $p = 0.671$) and 'AED only' patients (AOR:1.26, 95% CI: 0.25–6.38, $p = 0.778$).

Discussion

In this study, our results demonstrated that the combination of bystander-initiated CPR and public-access AED use was significantly associated with improved survival in this setting, highlighting the importance of implementing BLS education programs and the availability of public-access AEDs in school settings. To our knowledge, this is the first nationwide observational study to investigate the prognostic impact of BLS on non-traumatic OHCA occurring during school-supervised sports activities in schoolchildren, which has not been extensively studied before. Therefore, this study has important implications for improving OHCA management in school settings, and ultimately, improving patient outcomes.

The present study demonstrated that the combination of bystander CPR and AED application resulted in a significantly higher proportion of 1-month survival with favorable neurological outcomes compared to the absence of BLS; however, in cases where only CPR or AED was used, the intervention appeared to be less effective than the combination of both interventions. Our findings were consistent with those of our previous report focusing on all cases of pediatric OHCA occurring on school campuses[13] and a report on public locations among the general population in Osaka Prefecture.[25] A similar result was found in a study in South Korea, which showed that in cases where bystander-CPR was received, the survival rate of

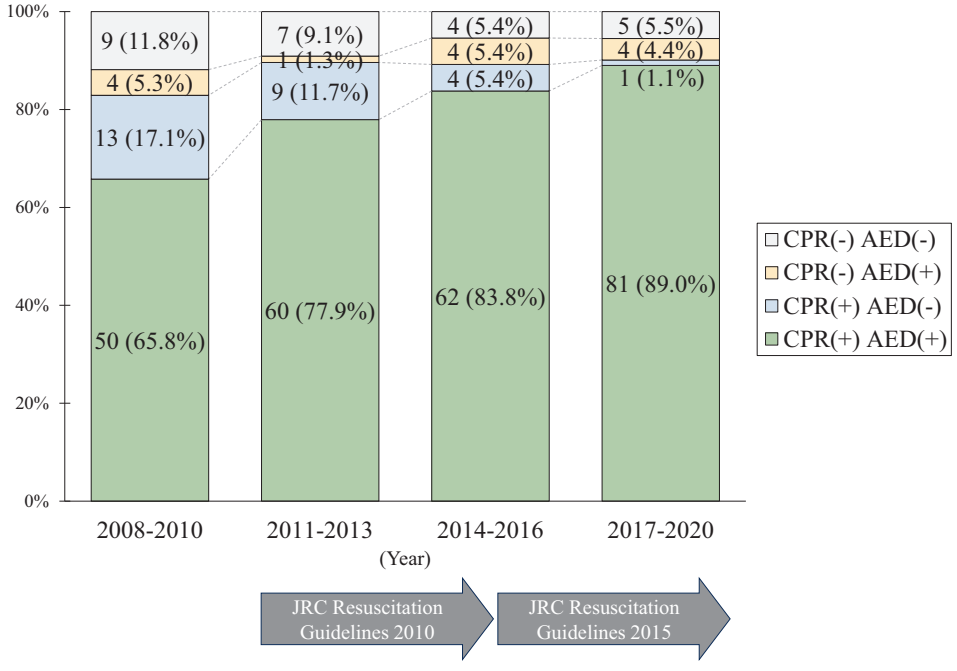

Fig. 2 – Change in the Proportion of Types of Basic Life Support by Bystanders to OHCA Patients and Effective period of the Japan Resuscitation Council Resuscitation Guidelines 2010 and 2015.

Table 1 – Characteristics of eligible patients according to the application of public-access AED and bystander-initiated CPR.

	Total	Application of public-access AED and bystander-CPR								P-values
		CPR+AED		CPR only		AED only		No CPR/AED		
Total, *n* (%)	318	253	(79.6%)	27	(8.5%)	13	(4.1%)	25	(7.9%)	
Educational level, *n* (%)										0.277
Elementary school	40	27	(67.5%)	7	(17.5%)	2	(5.0%)	4	(10.0%)	
Junior high school	106	83	(78.3%)	8	(7.5%)	6	(5.7%)	9	(8.5%)	
High school/Technical college	172	143	(83.1%)	12	(7.0%)	5	(2.9%)	12	(7.0%)	
Age, mean (SD)	14.7	14.8	(2.5)	13.9	(2.7)	14.5	(1.9)	14.2	(2.8)	
Minimum age – maximum age	6–19		6–19		7–17		11–17		8–18	
Location of arrest, *n* (%)										0.163
School Gymnasiums	71	60	(84.5%)	2	(2.8%)	4	(5.6%)	5	(7.0%)	
Schoolyards	142	115	(81.0%)	10	(7.0%)	7	(4.9%)	10	(7.0%)	
School swimming pool	30	21	(70.0%)	7	(23.3%)	1	(3.3%)	1	(3.3%)	
Other places at school	8	7	(87.5%)	0	(0.0%)	0	(0.0%)	1	(12.5%)	
Sports facilities outside school	34	27	(79.4%)	3	(8.8%)	1	(2.9%)	3	(8.8%)	
Other places outside school	33	23	(69.7%)	5	(15.2%)	0	(0.0%)	5	(15.2%)	
Sports events, *n* (%)										0.629
Long-distance running	70	57	(81.4%)	4	(5.7%)	5	(7.1%)	4	(5.7%)	
Football/Futsal	44	37	(84.1%)	2	(4.5%)	2	(4.5%)	3	(6.8%)	
Basketball	40	33	(82.5%)	2	(5.0%)	1	(2.5%)	4	(10.0%)	
Swimming	33	25	(75.8%)	6	(18.2%)	1	(3.0%)	1	(3.0%)	
Baseball	25	20	(80.0%)	3	(12.0%)	1	(4.0%)	1	(4.0%)	
Other	106	81	(76.4%)	10	(9.4%)	3	(2.8%)	12	(11.3%)	
Situation at the time of arrest, *n* (%)										0.383
During physical education class	130	110	(84.6%)	10	(7.7%)	5	(3.8%)	5	(3.8%)	
During club activities	143	106	(74.1%)	13	(9.1%)	7	(4.9%)	17	(11.9%)	
During competitions or sports festivals	17	13	(76.5%)	2	(11.8%)	1	(5.9%)	1	(5.9%)	
Other	28	24	(85.7%)	2	(7.1%)	0	(0.0%)	2	(7.1%)	
Sex, *n* (%)										0.022
Male	257	213	(82.9%)	18	(7.0%)	9	(3.5%)	17	(6.6%)	
Female	61	40	(65.6%)	9	(14.8%)	4	(6.6%)	8	(13.1%)	
Origin of arrest, *n* (%)										0.046
Cardiac origin	303	244	(80.5%)	25	(8.3%)	13	(4.3%)	21	(6.9%)	
Non-cardiac origin	15	9	(60.0%)	2	(13.3%)	0	(0.0%)	4	(26.7%)	
First documented rhythm, *n* (%)										<0.001
VF	273	228	(83.5%)	22	(8.1%)	12	(4.4%)	11	(4.0%)	
non-VF	45	25	(55.6%)	5	(11.1%)	1	(2.2%)	14	(31.1%)	
Witness of arrest, *n* (%)										0.003
Witnessed by bystanders	286	235	(82.2%)	22	(7.7%)	11	(3.8%)	18	(6.3%)	
Not witnessed	32	18	(56.3%)	5	(15.6%)	2	(6.3%)	7	(21.9%)	
Dispatcher instruction, *n* (%)										<0.001
Yes	163	139	(85.3%)	15	(9.2%)	6	(3.7%)	3	(1.8%)	
No	155	114	(73.5%)	12	(7.7%)	7	(4.5%)	22	(14.2%)	
Time from call to contact with patient by EMS, min, mean (SD)	8.2	8.3	(3.3)	7.5	(2.7)	8.7	(3.6)	8.2	(5.5)	0.683
Time from call to hospital arrival, min, mean (SD)	31.3	31.8	(14.1)	29.7	(15.6)	28.3	(12.3)	29.1	(9.2)	0.601

OHCA denotes out-of-hospital cardiac arrest; AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; VF, ventricular fibrillation; EMS, emergency medical service; SD, standard deviation

patients with AED (63.1%) was higher than patients with only chest compression (44.2%).[26] The superiority of the combined approach is likely due to the complementary roles of CPR and AED in OHCA management. CPR helps to maintain blood flow to vital organs until defibrillation is available or medical personnel arrive.[27] In contrast, an AED delivers an electrical shock to the heart, which helps restore normal rhythm. Thus, while CPR alone can provide temporary support until defibrillation is initiated, the use of AED alone cannot provide the continuous circulatory support required to maintain vital organ function. The prompt initiation of CPR and defibrillation with an AED can increase the likelihood of survival and reduce the risk of neurological damage.

Our study showed an increase in the proportion of patients with OHCA receiving both bystander CPR and AED use during school-supervised sports activities from 2008 to 2020. This positive finding may be attributed to several factors, such as increased awareness and training regarding BLS among teachers, staff, and students, as well as the increased availability and accessibility of AEDs in

Table 2 – Outcomes of OHCA according to the application of public-access AED and bystander-CPR.

	Total		Application of public-access AED and bystander-CPR								P-values
			CPR+AED		CPR only		AED only		No CPR/AED		
	(*n* = 318)		(*n* = 253)		(*n* = 27)		(*n* = 13)		(*n* = 25)		
Shock delivery by public-access AED, *n* (%)	217	(68.2%)	211	(83.4%)	0	(0.0%)	6	(46.2%)	0	(0.0%)	<0.001
Prehospital ROSC, *n* (%)	178	(56.0%)	159	(62.8%)	10	(37.0%)	3	(23.1%)	6	(24.0%)	<0.001
One-month survival, *n* (%)	210	(66.0%)	181	(71.5%)	13	(48.1%)	7	(53.8%)	9	(36.0%)	<0.001
One-month survival with favorable neurological outcome, *n* (%)	187	(58.8%)	164	(64.8%)	11	(40.7%)	5	(38.5%)	7	(28.0%)	<0.001

OHCA indicates out-of-hospital cardiac arrest; AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; ROSC, return of spontaneous circulation

Table 3 – Factors associated with 1-month survival with favorable neurological outcome after OHCA.

	One-month survival with favorable neurological outcome		Univariable analysis		Multivariable analysis*	
	n / N	(%)	OR (95% CI)	P-value	Adjusted-OR (95% CI)	P-value
Application of public-access AED and bystander-CPR						
CPR+AED	164/253	(64.8%)	4.74 (1.91–11.78)	0.001	3.97 (1.32–11.90)	0.014
CPR only	11/27	(40.7%)	1.77 (0.55–5.65)	0.337	1.35 (0.34–5.29)	0.671
AED only	5/13	(38.5%)	1.61 (0.39–6.64)	0.512	1.26 (0.25–6.38)	0.778
No CPR/AED	7/25	(28.0%)	ref.		ref.	

OHCA indicates out-of-hospital cardiac arrest; AED, automated external defibrillator; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; OR, odds ratio; CI, confidence interval

* In a logistic regression model, ORs were adjusted for educational level, location of arrest, sports events, situation at the time of arrest, sex, origin of arrest, witness of arrest, dispatcher instruction, and time from call to contact with patient by EMS.

school settings. The Japan Circulation Society recommends that all schools have an AED in a visible location.[28] In Japan, nearly all elementary, middle, and high schools have at least one AED per school, and 90% of the schools provided BLS training to teachers, including AED use, in 2015.[29] Our results confirm that early defibrillation by bystanders is possible with nationwide efforts to implement public access defibrillation programs in school settings.

The overall proportion of OHCA patients who survived for 1-month with a favorable neurological outcome in this study was 58.8%. Although studies specifically addressing OHCA occurrences during sports activities in schoolchildren are scarce, previous systematic reviews have reported varying survival rates depending on the situation and age groups involved. For example, a systematic review encompassing 19 studies on exercise-related OHCA across diverse age groups indicated a median survival rate to hospital discharge of 32% (interquartile range: 24%–49%).[17] Another review of 9 studies focusing on OHCA occurring in school settings reported survival rates to hospital discharge or at one month ranging from 31.9% to 71.2%.[7] Furthermore, another review showed an average survival rate of 13.2% (95% CI: 12.6–13.9%) for the subgroup of OHCAs among children.[30] Thus, the survival rate observed in our study can be considered relatively high. Considering that approximately 80% of the patients in this study received both bystander CPR and AED applications, the observed high survival rate could be attributed to the efforts made in BLS training and the dissemination of public-access AED in schools across Japan.

While sports-related OHCA cases in children and young adults are rare in relation to the total number of sports activities, they do occur and can have devastating consequences. The sports with the highest observed incidences in our study were long-distance running, football/futsal, basketball, swimming, and baseball. Together with other sports, these accounted for approximately one-third of all cases. It is important to recognize that cardiac arrest, while uncommon, can happen in any sporting context and represents a significant risk that warrants attention. Meanwhile, the 1-month survival with favorable neurological outcomes across all sports in our study ranged from 48.0% to 66.7%. This is significantly higher compared to the survival rate of 29.9% observed in 2014, which was reported in the study that investigated OHCA of cardiac origin among school-aged children (6–17 years old) occurring in all locations in Japan.[31] These findings suggest that the current measures for the prevention of sudden death under school supervision are effective

to a significant degree, regardless of sports events. However, our ultimate goal is zero deaths from cardiac events in this setting, which is in line with the Japan Circulation Society's statement: "Aiming for zero deaths; prevention of sudden cardiac death in schools".[28] To achieve this goal, it may be beneficial to consider the specific needs of each sport. For example, regarding the location of AEDs for long-distance running, where students are dispersed over a large area, multiple AEDs may need to be strategically placed along the course. However, in events where the action is concentrated in a small area, such as basketball or swimming, it may be sufficient to place one AED nearby.

To achieve "Aiming for zero deaths",[28] the important thing is to be able to deliver an AED shock within 5 mins, as recommended in the guidelines[32,33]; this would require each school facility to have multiple AEDs deployed in appropriate locations. However, as of 2015, almost all schools in Japan have at least one AED, but only approximately 20% of schools have two or more AEDs[29]; therefore, further efforts are needed to disseminate AEDs. In addition, our results indicated that the percentage of AED applications was relatively low when OHCAs occurred during club activities; that is, public-access AEDs were not utilized in approximately 20% of OHCA cases in this setting. In Japan, because many schools have AEDs in areas with limited access to school buildings,[29] bystanders may not have been able to access AEDs during club activities, particularly after school hours, in some OHCA cases. AEDs should be located in unlocked areas that are accessible 24 h a day, year-round, for unexpected cardiac arrests that may occur outside school hours.[28]

Limitations

Our study had several limitations. First, as this was an observational study, we did not establish a causal relationship between BLS and survival outcomes. There may be unmeasured confounding factors, such as medical history, results of heart examinations, current medications, hospital care, and other relevant lifestyle factors that could have influenced our results. Additionally, data on bystander characteristics (e.g., sex, age, affiliation, and experience with previous CPR training) and CPR quality (e.g., depth and rate of chest compressions) were not available in our study, which could have affected the effectiveness of BLS. Second, although the SPIRITS database provides comprehensive coverage of pediatric OHCA cases in school settings in Japan, there may still be cases that were not included in the registry, as noted in a previous paper.[19] This is due to possible data entry errors in the data linkage items for the development of the SPIRITS registry and the fact that cases that were not transported to the hospital by EMS were not registered. Third, despite its significant social impact, the occurrence of OHCA in this setting was rare and the number of subjects was small. Therefore, subgroup analyses based on the important factors could not be performed. The American Heart Association guidelines state that pediatric life support guidelines apply to all children aged 0–18 years, but also recommend that basic life support guidelines for adults should be followed for those with signs of puberty and beyond.[34] Therefore, it is particularly important to analyze patients with OHCA according to age group. For example, given that the subjects of this study are elementary, middle, and high school/technical college students, who are predominantly aged between 6 and 18 years, the analysis could be stratified into two age groups: younger (6–11 years old) and older (12 years old and above). Prospective registration of OHCA cases in the SPIRITS database and a comprehensive investigation of this topic are topics for future research.

Conclusions

In conclusion, our nationwide observational study demonstrated that the combination of CPR and AED use as basic life support performed by bystanders for non-traumatic OHCA during school-supervised sports activities improved outcomes. Our findings highlight the importance of BLS education and AED availability in school settings as well as the prompt initiation of BLS in OHCA patients.

Authors' contributions

KK, MA, TI, and TK designed the SPIRITS and acquired the data. KK and TS managed the data. KK, SM, MA, MN, KN, YK, TS, and TK designed the study. KK and SM performed the statistical analyses. KK, SM, MA, TI, KN, TS and TK drafted the manuscript. All authors have read and revised the manuscript critically for important intellectual content and have agreed to the submission of the manuscript for publication.

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CRediT authorship contribution statement

Kosuke Kiyohara: . **Satoshi Matsui:** Formal analysis, Investigation, Writing – original draft. **Mamoru Ayusawa:** Data curation, Writing – review & editing. **Takeichiro Sudo:** Data curation, Writing – review & editing. **Masahiko Nitta:** Data curation, Writing – review & editing. **Taku Iwami:** Supervision, Writing – review & editing. **Ken Nakata:** Supervision, Writing – review & editing. **Yuri Kitamura:** Resources, Writing – review & editing. **Tomotaka Sobue:** Resources, Writing – review & editing. **Tetsuhisa Kitamura:** Conceptualization, Formal analysis, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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