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FIFA Initiatives Improved Survival After Loss of Consciousness During Football Games

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ABSTRACT

Loss of consciousness (LOC) during football games is associated with very high mortality rates. In order to address football medical emergencies, in 2013 FIFA implemented the "FIFA 11 steps to prevent sudden cardiac death" program and distributed the FIFA Medical Emergency Bag. The purpose of this work was to identify independent survival factors after LOC on the pitch and to investigate the effectiveness of the FIFA initiatives. An internet search was performed to identify football players suffering LOC on the pitch between 1990 and 2021. A total of 268 cases could be identified and were dichotomized according to the implementation date of the FIFA medical emergency bag. There was 55 % mortality after LOC, while cardiogenic LOC was more often (82 % vs. 20 %) fatal than traumatic LOC. Mortality in developing countries was higher than in developed countries. From the year 2013 survival improved significantly for both traumatic and cardiogenic cases. The location of the LOC significantly influenced survival (OR: 0.20 and $p < 0.001$). LOC on the football field is associated with increased mortality and requires separate monitoring based on a traumatic vs. non-traumatic cause. FIFA initiatives significantly reduced mortality after LOC but significant differences were identified between developed and developing countries.

Introduction

Football is the most popular sport in the world and clubs are making more money than ever [1–3]. Increasingly high wages and financial incentives along with the social recognition for footballers in the top leagues lead to ever growing competition. The intensity of efforts pushes the players to their limits, making them prone to cardiovascular events and musculoskeletal injury. Medical emergencies during football games, in particular those involving loss of consciousness (LOC), may be disastrous as they are associated with an unfavorable prognosis [4]. The devastating social impact of sudden death (SD) occurring on the field could demotivate people from participating in athletic activities and could hinder the goal of promoting sports [5].

It is of grave importance to identify the risk and factors related to LOC in order to set and implement treatment protocols and shorten the intervention time. In recent decades more systematic attempts have been made to record the extent of this issue and to identify the underlying causes [6]. This has led to specific preventive and supportive measures established by local and international authorities. To this end and mainly to address sudden cardiac death (SCD), the Fédération internationale de football association (FIFA) has applied the "FIFA 11 steps to prevent SCD" program (FIFA 11) since 2013 [7, 8]. Furthermore, all 209 member associations were provided the FIFA Medical Emergency Bag (FMEB) [7]. The FMEB basic inventory is meant to provide a worldwide minimum standard of football emergency care. Despite these efforts the issue of LOC and SD in football is far from resolved.

We tried to investigate whether the measures initiated in 2013 had a significant positive effect on the survival of footballers collapsing on the pitch and to identify possible prognostic factors in the era before and after the FMEB.

Material and Methods

Patient population

Data of footballers who suffered cardiogenic or traumatic LOC on the pitch between 1990 and 2021 were retrospectively collected and analyzed [9–17]. An extensive Internet search was conducted using a common Internet browser and search engine. Cases without confirmed diagnosis leading to LOC or with incomplete data were excluded from the study. Parameters analyzed included date, location, and cause of LOC, sex, age, resuscitation performed or not, and final outcome. The parameter "location" refers to the country where the LOC took place. Countries were categorized as developed and developing according to United Nations (UN) criteria. A major criterion is the Human Development Index, which includes the Health Index. This represents an index of the health services provided [18, 19]. The cause of LOC was either cardiogenic or traumatic. The final outcome was defined as either survival or death resulting from the cause of LOC.

All data retrieved were publicly available, thus no informed consent was required.

Statistical analysis

Age is presented as mean ± standard deviation (SD). Categorical variables are given in terms of counts (n) and percentages.

Data were gathered independently from two researchers leading to two data banks. The results were compared using kappa statistic, and eventually the two data banks were merged into a final one.

The impact of the possible predictors on survival was assessed by performing a binomial regression analysis. Location and cause of LOC, sex, age, resuscitation performed or not, and recent past time after application of FMEB constituted the independent variables, while final outcome–death or survival–represented the dependent variable in the regression analysis. Variables were first tested on a univariate binary logistic regression model and those exceeding the threshold of statistical significance were included in a multivariate logistic regression model in order to control for possible relationship between them. This two-step analysis allows for identification of independent prognostic factors by estimating the association of each parameter with survival when controlling for other variables. P values of less than 0.05 were considered to be statistically significant. Odds ratios (OR) with a 95 % confidence interval (CI) were calculated. The fit of our model to the data was evaluated with the likelihood ratio chi-square test (LRT), pseudo-R-squared (R^2) as well as the Hosmer–Lemeshow test (HLT). The specificity and sensitivity of the model were also calculated. Furthermore, the population was dichotomized according to the application date of the FMEB. Namely, footballers who collapsed on the pitch before the application of the FMEB constituted the bFMEB group, while those with LOC after the application made up the aFMEB group. The two-step logistic regression was once again used to analyze possible correlation between the variables and the final outcome regarding survival. Differences between these two cohorts were evaluated using the independent t-test for age and Pearson's chi-squared test for categorical variables.

Statistical analyses were performed using the Statistical Package for Social Sciences (Version 24.0; IBM Corp., Armonk, NY, USA).

Results

Patient population analysis

In a time period of 30 years (1990–2020), 268 cases of LOC on the pitch were identified, and of those, 98.9 % (265) involved male athletes and 1.1 % (3) female. The mean age of our cohort was 26.6 years (SD 6.6 years). Cohen's kappa was 0.87, representing an almost perfect inter-rater reliability. In 149 cases LOC resulted in death. Dichotomization according to the date of FMEB distribution resulted in two comparable groups in terms of group size and characteristics, namely age, gender, and development status of the country in which the game took place. A significant difference was found between the two groups regarding the cause and outcome of LOC. Before implementation of FMEB, cardiogenic LOC was more frequent, while the traumatic LOC predominated afterwards. Noteworthily, the survival rate increased significantly ($p < 0.001$) (▶ **Table 1**).

In our analysis, we found distinct differences regarding survival in relation to the mechanism (traumatic and cardiogenic) and the location (developed and developing countries) of LOC (▶ **Table 2**). The mortality rate of traumatic LOC after FMEB has been significantly reduced in both subgroups of developed and developing

▶ **Table 1** Descriptive data of overall LOC and groups dichotomized according to FMEB implementation (bFMEB vs. aFMEB).

Variables	Total	bFMEB (n = 132)	aFMEB (n = 136)	p Value	OR
Age	26.6 ± 6.6	26.4 ± 5.5	26.8 ± 7.4	0.579	NA
Male	265 (99 %)	131 (99 %)	134 (99 %)	0.579	0.51 (0.05–5.71)
Developed country	149 (55 %)	67 (51 %)	82 (60 %)	0.116	1.47 (0.91–2.39)
Traumatic	116 (43 %)	45 (34 %)	71 (52 %)	0.003	2.11 (1.29–3.46)
Cardiogenic	152 (57 %)	87 (66 %)	65 (48 %)	< 0.001	0.39 (0.24–0.64)
Resuscitation	136 (51 %)	77 (58 %)	59 (43 %)	0.014	0.55 (0.34–0.89)
Death	149 (55 %)	94 (71 %)	40 (55 %)	< 0.001	0.28 (0.16–0.46)

▶ **Table 2** Mortality rates according to the mechanism (traumatic vs. cardiogenic), location (developing vs. developed countries), and time of LOC (bFMEB vs. aFMEB).

	Cardiogenic			Traumatic		
	Total	bFMEB	aFMEB	Total	bFMEB	aFMEB
All	82 % (126/154)	84 % (78/93)	79 % (48/61)	20 % (23/114)	33 % (14/42)	13 % (9/72)
Developed	75 % (56/75)	75 % (36/48)	74 % (20/27)	4 % (3/74)	8 % (2/24)	2 % (1/50)
Developing	89 % (70/79)	93 % (42/45)	82 % (28/34)	50 % (20/40)	67 % (12/18)	36 % (8/22)

countries ($p < 0.001$). However, developed countries have shown a more effective survival improvement. As expected, the mortality rate of traumatic LOC was higher in developing countries compared to developed countries in both bFMEB and aFMEB groups.

Univariate regression analysis

Since male athletes represented the overwhelming majority (98.9 %) of our cohort, no correlation analysis between sex and survival was feasible.

Our univariate analysis identified younger age, recent past time after FMEB, location of developed countries, and traumatic cause of LOC as beneficial prognostic factors of survival after LOC. A cardiogenic cause of LOC and resuscitation performed exhibited a negative impact on survival (▶ **Table 3**).

In order to evaluate the impact of the introduction of FMEB on survival, we performed a similar univariate regression analysis separately for b- and aFMEB (▶ **Table 4**).

Multivariate regression analysis

LRT showed that the logistic regression model brought significant improvement compared to no model ($p < 0.001$), while HLT presented no significance ($p = 0.284$), so both tests indicated a good fit for our model. Nagelkerke R^2 was 0.62, indicating a strong relationship between the predictors and outcome. Furthermore, the model presented a high specificity (77 %) and sensitivity (91 %). Recent past time after FMEB and location of developed countries were identified as positive independent predictors of survival, while older age, cardiogenic cause of LOC, and reanimation showed an independent negative effect upon survival (▶ **Table 5**). The logistic regression equation in this case would be: log_e *(odds of Outcome) = 2.34 + 0.5 x (Age) – 1.26 x (Recent past time after FMEB) – 2.09 x (Developed country) – 0.87 x (Trauma) + 1.4 x (Cardiogenic) + 1.44 x (Reanimation)* or: *Odds of Outcome = 10.34 x* $(1.05)^{(Age\ in\ years)}$ *x (0.28 x Recent past time after FMEB) x (0.12 x Developed country) x (0.42 x Trauma) x (4.06 x Cardiogenic) x (4.24 x Reanimation)*

▶ **Table 3** Univariate regression analysis of survival after LOC.

Variable	p Value	OR (95 % CI)
Age	0.043	1.04 (1.00–1.08)
Recent past time after FMEB	< 0.001	0.27 (0.17–0.46)
Developed country	< 0.001	0.21 (0.12–0.36)
Trauma	< 0.001	0.08 (0.05–0.15)
Cardiogenic	< 0.001	17.80 (9.64–33.00)
Reanimation	< 0.001	10.98 (6.18–19.51)

The results of the multivariate regression analysis for each subgroup are shown in ▶ **Table 6**.

Discussion

Loss of consciousness on the football field is a disturbing and terrifying moment for the player and spectators [20]. Despite changes and advances in the treatment of LOC over the past 30 years, it remains a severe status with a high mortality of over 55 % [5, 6, 21]. It is thus very important to identify possible prognostic factors of survival and consequently explore possible points of influence for the future [7, 8]. To this context, we performed a multivariate regression analysis that identified a younger age of the athlete, a time frame after the FMEB application, and location of LOC in a developed country as independent beneficial predictors of survival, while a non-traumatic cause of LOC and resuscitation performed were negative prognostic factors [4].

According to our analysis, survival rates differ significantly between developed and developing countries. This may rely on the quicker availability of medical support and advanced medical infrastructure. The factor "developed country" showed an overwhelming odds ratio (OR 0.20) for survival after LOC in our models. According to our model if all other variables remained stable, odds that a footballer would die if LOC occurred in a developing country are 5 times greater compared to LOC occurring in a developed country. Noteworthily, the survival rate in a developed country

▶ **Table 4** Univariate regression analysis of survival after LOC according to subgroups bFMEB and aFMEB.

	bFMEB		aFMEB	
Variable	**p Value**	**OR (95 % CI)**	**p Value**	**OR (95 % CI)**
Age	0.704	1.01 (0.95–1.08)	0.039	1.06 (1.00–1.12)
Developed country	< 0.001	0.21 (0.09–0.50)	< 0.001	0.20 (0.10–0.43)
Trauma	< 0.001	0.14 (0.06–0.32)	< 0.001	0.05 (0.02–0.12)
Cardiogenic	< 0.001	11.41 (4.74–27.4)	< 0.001	23.87 (9.44–60.37)
Reanimation	< 0.001	4.86 (2.16–10.94)	< 0.001	26.74 (10.56–67.67)

▶ **Table 5** Multivariate regression analysis of survival after LOC.

Variable	**p Value**	**OR (95 % CI)**	**Co-efficient**
Age	0.034	1.05 (1.00–1.11)	0.05
Recent past time after FMEB	0.001	0.28 (0.14–0.58)	−1.26
Developed country	< 0.001	0.12 (0.06–0.27)	−2.09
Trauma	0.177	0.42 (0.12–1.48)	−0.87
Cardiogenic	0.035	4.06 (1.11–14.86)	1.40
Reanimation	0.002	4.24 (1.70–10.56)	1.44
Constant		10.34	2.34

after traumatic LOC is 96 %, while in a developing country it is just 50 %. In a literature review, Harmon et al. published similar observations [4, 11]. Taking into account the global interest in football, there is a need for globally active associations, like FIFA, to take action in order to partially overcome these hurdles.

FIFA realized the need to implement global standards to avoid and to cope with injuries and SCD. The FIFA 11 + program focuses more on avoiding injuries of the extremities, the FIFA 11 program on preventing sudden cardiac arrest (SCA), and the FMEB implementation aims to address life-threatening medical emergencies. [8]. Since the initiation of the FIFA 11 program and the distribution of the FMEB, the mortality rate after LOC fell impressively from 71 % to 40 % according to our analysis. Our model shows that the chances of survival (OR 0.28) after implementation of FMEB rose by a factor of 3.57. However, the improvement in survival rate after cardiogenic LOC was marginal, increasing from 16 % to 21 %. Mainly players in developing countries benefited from the FIFA11 program, where the survival rate rose from 7 % to 18 %, while the survival rate in developed countries remained almost unchanged at 25 %. Since the survival rates for out-of- and in-hospital SCA are reported at about 10 % and 30 %, respectively, the survival rates of cardiogenic LOC in our cohort are in line with the pertinent literature [22]. Furthermore, as they lie on the upper end of the reported outcomes, especially in developed countries, a further improvement might be unlikely.

On the other hand, the mortality rate due to traumatic LOC fell from 33 % to 13 %. Once again, improvement was more apparent in developing countries. Even though the survival rate in developing countries significantly improved from 33 % to 64 % after the FMEB application, it is still far from the impressive current survival rate of 98 % in developed countries. We assume that distinguishing between cardiogenic or traumatic LOC and different responses to each cause of the LOC may be of great importance for the future to further improve the outcome for injured players [23–25].

Egger et al. observed regional variations and emphasized the need of access to an AED and CPR teaching for players and coaches everywhere [6]. Addressing the traumatic cause of LOC might be crucial to further lower mortality, but this must be done in such a way that developing countries can effectively handle, as players in these countries are at a higher risk.

Eventually, prevention of SCA provided a substantial contribution to survival rate improvement, as there was a shift from non-traumatic to traumatic LOC in our study. Cases of non-traumatic LOC dropped 33 % from the bFMEB to the aFMEB era. Prevention in advanced health systems led to a case reduction of 44 %, while in developing countries a lower reduction of 25 % was observed. Probably stricter supervision of the prevention program application and provision of medical equipment are necessary in developing countries.

Unfortunately, while the incidence of cases with cardiogenic LOC appears to be falling, the incidence of traumatic LOC is growing. This is probably due to the increasing competition in modern football. In 2006 FIFA developed the FIFA 11 + program to prevent non-contact injuries, which it has promoted and disseminated since 2009, and it has proved to be an effective initiative [26]. In order to lower the incidence of traumatic head injuries, FIFA adapted relevant rules. As supported by Beaudouin et al., the risk of head injuries can be reduced by changing the rules [27]. Even though traumatic LOC has a lower mortality rate compared to cardiogenic LOC it should not be underestimated. The mortality rate after LOC especially in developing countries still remains high, and morbidity has not yet been comprehensively studied. An extensive discrepancy has been reported between protocols and medical practice upon management of traumatic brain injury [28, 29]. This calls for an international initiative similar to FIFA11 and FIFA11 + . A structured standardized preventive and therapeutic program should be planned and applied.

The retrospective nature of our study makes it inherently limited, especially as only secondary data/sources were evaluated. It should be kept in mind that there is a great risk of publication and selection bias. A reliable international database of footballers suffering LOC on the field similar to the FIFA-Sudden Death Registry (FIFA-SDR) is required in order to identify possible modifiable prognostic factors of survival and to proceed in planning and applying an international prevention and therapy program.

▶ **Table 6** Multivariate regression analysis of survival after LOC according to subgroups bFMEB and aFMEB.

	bFMEB			aFMEB		
Variable	**p Value**	**OR (95 % CI)**	**Coefficient**	**p Value**	**OR (95 % CI)**	**Coefficient**
Age	0.518	0.97 (0.88–1.07)	−0.3	0.007	1.10 (1.03–1.18)	0.10
Developed country	<0.001	0.10 (0.32–0.33)	−2.27	<0.001	0.11 (0.03–0.38)	−2.20
Trauma	0.961	1.06 (0.12–9.30)	0.06	0.033	0.13 (0.02–0.85)	−2.03
Cardiogenic	0.022	11.81 (1.44–97.05)	2.47	0.747	0.70 (0.08–6.10)	−0.36
Reanimation	0.170	2.40 (0.69–8.42)	0.88	<0.001	17.66 (3.61–86.41)	2.87
Constant		0.58	−0.55		20.40	3.02

Conclusions

The implementation of FIFA11 prevention program and the application of the FMEB significantly reduced mortality after LOC, in particular cardiogenic LOC. In future, LOC should be closely monitored regarding traumatic vs. non-traumatic cause. Prospectively open standardized databases are necessary in order to further improve the outcome after LOC. The relevant international supporting and preventive programs as well as standard operating procedures should consider the limitations of the local health systems and be feasible globally in order to further improve the outcome for the affected players in both developed and developing countries.

Conflict of Interest

The authors declare that they have no conflict of interest.

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