Are Die-Hard Football or Other Sports Fans at Risk of Cardiovascular Events?

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Abstract: Trigger factors such as earthquakes, war, and terrorism have been shown to increase the risk of cardiovascular events in different studies. Similarly, strong emotions and psychological stress have been associated with myocardial infarction, symptomatic arrhythmias, and sudden cardiac death. Die-hard soccer, rugby, football, and baseball fans seem to be at risk of cardiac events, particularly in individuals with prior history of coronary artery disease. Transient hemodynamic changes, endothelial dysfunction, and an overwhelming sympathetic nervous system stimulation appear to affect cardiac hemostasis creating a procoagulant and arrhythmogenic environment. High-risk behaviors such as tobacco abuse and binge drinking appear to contribute to this risk generating a proinflammatory state characterized by elevated levels of endothelin-1 and overexpression of sCD40L, sVCAM-1, MCP-1, and TNF-alpha. The outcome of

The authors have no conflicts of interest to disclose.
Curr Probl Cardiol 2021;46:100743
0146-2806/$ – see front matter
https://doi.org/10.1016/j.cpcardiol.2020.100743

the game and unexpected results, especially among fans of the defeated team, seem to further correlate with adverse cardiovascular effects. (Curr Probl Cardiol 2021;46:100743.)

Introduction

Heart disease is the leading cause of cardiovascular mortality in the United States, with more than 655,000 deaths per year, accounting for 23% of total deaths in 2017. Cardiovascular disease costs around $219 billion each year to the US healthcare system, and these numbers continue to rise. Hypertension, tobacco use, and dyslipidemia are the key risk factors for heart disease, and about half of Americans have at least one of these 3 risk factors (Tables 1 and 2).[1-3]

A variety of trigger factors with cardiac implications have widely been studied for the past decade as part of a renewed interest in the identification of modifiable behaviors for the development of heart disease. Community triggers such as earthquakes, war, and terrorism have been shown to increase the incidence of cardiovascular events. Likewise, strong emotions appear to affect sports fans and spectators of intense sporting events.[4]

The role of strong emotions and psychological stress has been associated with myocardial infarction (MI), symptomatic arrhythmias, and sudden cardiac death in different studies.[5] The pathophysiology behind emotional stress and plaque rupture is currently under investigation and appears to be related to sympathetic nervous system dysregulation and catecholamine release mediated by sympathetic overactivity and cardiac repolarization abnormalities.[6,7]

Spectators of different sports, including soccer, rugby, baseball, and hockey, have been noticed to be at increased risk of cardiovascular events, including angina, acute coronary syndromes, and sudden cardiac death. Poor lifestyle habits, including binge drinking, fatty meal consumption, and tobacco abuse, appear to rise during sporting events and have been implicated with the development of cardiovascular manifestations, especially among those spectators with a prior known history of coronary artery disease.[7,8] Similarly, environmental stressors such as pollution, ambient temperature, atmospheric pressure, and participation in traffic seem to play a role in the multifactorial nature of cardiovascular events in this population.

Table 1. Cardiovascular events in sports fans

Studies	Sporting event	Study population	Cardiovascular event
Wilbert-Lampen U et al, 2008	Soccer (FIFA World cup 2006)	Greater Munich area	Increase of STEMI by a factor of 2.49 Increase of by a factor of NSTEMI 2.61 Increase of symptomatic arrhythmia by a factor of 3.07
Niederseer D et al, 2013	Soccer (FIFA World cup 2006)	Germany (region of Bavaria)	No increase in total cardiac events
Olsen P et al, 2015	Rugby World Cup (RWC) tournaments	New Zealand	Semi-final loss in 2003 was associated with a 50% ($P < 0.01$) increase in pooled heart failure admissions and a 20% ($P < 0.05$) increase in pooled acute coronary syndromes admission. Increase in heart failure in women with a two-fold increase on match day and 2-days post
Onozuka D et al, 2018	Professional Baseball Championship Series	Japan	Pooled relative risk of outside hospital cardiac arrest 1.033 (95% confidence interval 1.012 to 1.055; $P = 0.002$)
Kloner RA et al, 2009	American football super bowl 1980 and 1984	Los Angeles	Circulatory deaths (1.3024 vs 1.0665 for control days, $P < 0.0001$) Deaths from ischemic heart disease (0.8551 vs 0.7143 for control days, $P < 0.0001$). Deaths from acute myocardial infarctions (0.2710 vs 0.2322 for control days, $P = 0.0213$). Super Bowl−related days during the winning 1984 game were associated with a lower rate of all-cause death (2.1870 vs 2.3205 for control days, $P = 0.0302$).

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Table 1. (*continued*)

Studies	Sporting event	Study population	Cardiovascular event
Barone-Adesi F et al, 2010	Soccer: World Cup 2002, the European Championship 2004 and the World Cup 2006	Italy	No increase in the rates of admission for AMI on the days of football matches involving Italy in either the single competitions or the 3 competitions combined
Wang H et al, 2020	Meta-analysis of soccer tournaments	Multiple countries	Of the 10 studies reported hospitalizations due to non-fetal acute cardiovascular events, the pooled RR was 1.17 (95% CI 1.01-1.36). Of the 10 studies reported cardiovascular mortality the pooled RR was 1.03 (95% CI 1.00-1.05). Pooling of 4 studies where their national teams lost the MFTs produced a RR for the mortality of 1.19 (95% CI: 1.09-1.30).

Table 2. Common Characteristics of people with cardiovascular events in sports events

Cardiovascular events	Characteristics	Study
STEMI	Men	Wilbert-Lampen U et al, 2008
	Women	Olsen P et al, 2015
	Prior history of cardiovascular disease	Kloner RA et al, 2009
		Wilbert-Lampen U et al, 2008
		Olsen P et al, 2015
		Kloner RA et al, 2009
		Wilbert-Lampen U et al, 2008
NSTEMI	Men	Wilbert-Lampen U et al, 2008
	Women	Olsen P et al, 2015
	Prior history of cardiovascular disease	Kloner RA et al, 2009
		Wilbert-Lampen U et al, 2008
		Olsen P et al, 2015
		Kloner RA et al, 2009
		Wilbert-Lampen U et al, 2008
Symptomatic arrhythmia	Men	Wilbert-Lampen U et al, 2008
	Women	Olsen P et al, 2015
	Prior history of cardiovascular disease	Wilbert-Lampen U et al, 2008
		Wilbert-Lampen U et al, 2008
Heart failure exacerbation	Women	Olsen P et al, 2015
Outside hospital cardiac arrests	Men	Onozuka D et al, 2018
	Elderly	Onozuka D et al, 2018
Cardiovascular death	Men	Kloner RA et al, 2009
	Women	Kloner RA et al, 2009

Pathophysiology

The mechanisms linking emotional response to sporting events with adverse cardiovascular outcomes involve their ability to cause dangerous arrhythmias and provoke myocardial ischemia. Acute mental stressors such as the ones experienced by spectators of emotionally-intense sporting events trigger 3 pathological processes that mediate these outcomes: endothelial dysfunction, sympathetic nervous system dysregulation, and arrhythmogenesis.[9]

Inherent endothelial dysfunction and exaggerated responses of the Sympathetic-Adrenal-Medullary System (SAMS) and Hypothalamic-Pituitary-Adrenocortical Axis are significant contributors to this pathological process. Similarly, high-risk cardiovascular behaviors such as binge-drinking, tobacco abuse, and fatty meal consumption have also been implicated.[10] These processes lead to adverse cardiovascular endpoints due to their ability to trigger myocardial supply-demand mismatches, acute thrombotic events, atherosclerotic plaque formation, and arrhythmogenesis.

Endothelial Dysfunction

Strong emotional responses can trigger endothelial and hemodynamic changes mediated by neuroendocrine dysregulation, increasing the risk of atherosclerotic plaque rupture.[10] Activation of SAMS results in endothelial dysfunction causing myocardial ischemia through a transient procoagulant state and increased afterload. The exact mechanism of this procoagulant state is still emerging. Current evidence suggests that epinephrine stimulates anticoagulant tissue-type plasminogen activator, factor VIII, Von Willebrand factor, and platelets. Overall, the procoagulant state predominates over the anticoagulant state. Some data suggest these endothelial alterations are prone to thrombosis due to an impaired ability to make tissue-type plasminogen activator while a maintained ability to secrete von Willebrand factor and fibrinogen.[4]

Plaque formation generates endothelium dysregulation and increased local vasoconstriction. This impaired regulation is most pronounced at points of coronary artery stenosis. The local vasoconstriction is coupled with systemic vasoconstriction due to decreased vagal tone while increased SAMS, rising heart rate, blood pressure, ventricular contraction, and vascular resistance. This unopposed rise in afterload and increased myocardial oxygen demand occurs along with a diminished coronary blood supply due to excessive coronary artery vasoconstriction-causing demand ischemia. Likewise, the sheer stress, blood viscosity, and inflammatory markers seen with SAMS activation increases the likelihood of disrupting an existing atherosclerotic plaque exacerbating ischemia even further.[4,9]

Another neuroendocrine system operating is the Hypothalamic-Pituitary-Adrenocortical Axis. The activation of this Axis increases the risk of plaque rupture and thrombosis acutely. It exerts these effects through corticotrophin releasing hormone (CRH) and cortisol. Elevations in the amount of cortisol lead to increased blood pressure, hyperglycemia, insulin resistance, inappropriate inflammatory response, and platelet function. Elevated CRH leads to increased levels of monocyte-endothelial cell adhesion, macrophage activation, and endothelin-1 release.[9] Patients with stress-associated MI related to World Cup Soccer matches had elevated levels of endothelin-1 in addition to other vasoconstrictive and inflammatory markers.[4]

Arrhythmogenesis

The arrhythmogenic potential of emotional response is threefold. First, as mentioned above, there is a reduced vagal tone and increased SAMS

activity.[9] This unopposed sympathetic activity promotes the formation of arrhythmia via catecholamine surges. Lastly, the emotional response to sporting events has some effect on the ability of the myocardium to repolarize in healthy and unhealthy tissue. In patients with a history of heart failure and coronary artery disease, these repolarization changes have been shown to be a strong predictor of sudden cardiac death.[11]

High-Risk Behaviors

The environment of sporting events and typical fan culture promotes high-risk behaviors that have been shown to adversely affect cardiovascular outcomes. Stadium food is typically high in fat content, and fatty meals cause endothelial dysfunction.[4,9] Heavy alcohol consumption specifically has been shown to impair ventricular function, precipitate arrhythmias such as atrial fibrillation, and cause endothelial dysfunction leading to impaired vasodilation and accelerated plaque formation.[12-14] Binge drinking, one or more days per week, is associated with an increased risk of cardiovascular death and mortality from all causes.[15] Even when not binge-drinking, alcohol is proarrhythmogenic and damages the structure of the myocardium leading to cardiomyopathy.[9,16-17] Depending on the outcome of the game, these already high-risk behaviors can be more prominent, as hostility-induced smoking from anxiety in spectators of the defeated team. These behaviors are also influenced by the mental stress created by the game. For example, depression and anger from a loss can lead to over-indulgence in high-risk behaviors like tobacco, alcohol abuse, and poor dietary choices.[4,9] Negative emotions are prospectively associated with the development and progression of cardiovascular disease. While positive emotions, like those that occur after the home team wins a high stakes game, have shown to be positively correlated with better outcomes like decreased risk of combined angina, nonfatal MI, and death.[18]

Football

American football is arguably the most popular sport in the United States. A study released in the *Journal of Clinical Hypertension* looked at 11 New York Giants and New York Jets fans using baseball fans as a control group. Comparisons were made among average pregame and game time values for heart rate (HR), mean arterial BP (MAP), and the "double" product (DP) of the 2 parameters. Football fans showed an increase in MAP and DP compared to control baseball fans, yet results did not reach statistical significance between groups.[19]

Kloner RA et al published in *the American Journal of Cardiology* a study collecting data on Super Bowl games, and is to date, the most comprehensive analysis of football fans and cardiovascular events, linking psychological stress and clinical outcomes. This study aimed to determine whether there were changes in death rates when a local football team in Los Angeles participated in the Super Bowl. Results showed that when the local team lost, there were higher daily death rates in LA for total deaths (2.4482 vs 2.0968 for control days, $P < 0.0001$), circulatory deaths (1.3024 vs 1.0665 for control days, $P < 0.0001$), deaths from ischemic heart disease (0.8551 vs 0.7143 for control days, $P < 0.0001$), and deaths from acute myocardial infarctions (0.2710 vs 0.2322 for control days, $P = 0.0213$). Interestingly, when the local team won the Super Bowl, lower rates of all cause-mortality were observed.[20]

Soccer

Soccer is the most popular sport in the world and arguably the most investigated sport with respect to spectatorships and cardiovascular health. Several studies have found significant associations between watching matches and increased cardiovascular events,[5,10,21] while others have found no distinct association.[22,23]

One of the most significant studies on soccer spectators was published in 2008 in *the New England Journal of Medicine*. Wilbert-Lampen et al examined the incidence of acute cardiovascular events during the FIFA World Cup in the summer of 2006 in Germany. The study looked at patients who were preclinically diagnosed with acute coronary syndrome, symptomatic cardiac arrhythmias, or cardiac arrest. Results showed an increased incidence of cardiac events of 2.66 times when the German team played compared to control days (95% confidence interval [CI], 2.33-3.04; $P < 0.001$). For men, the incidence ratio was 3.26, and for women 1.82, both of these results were also statistically significant.[5]

This study went a step further and analyzed the trends during individual World Cup matches. Remarkably, the number of cardiovascular events was higher on the day Germany beat Poland with a goal in the last minute than it was for the day Germany beat Costa Rica with a less intense finish. This demonstrated that a same game outcome—German victory—could yield different results. Moreover, the number of cardiovascular events was higher during the games against Poland or Costa Rica than it was on the day Germany beat Ecuador, a game played when Germany was already qualified for the next round of the tournament. Furthermore, the knockout games showed a significant increase in

cardiovascular events compared to the control period—especially a game against Argentina in which Germany won after a penalty shoot. Interestingly, this study revealed not only an association between viewership and cardiac events but also to the intensity of the game being watched.[5] Similarly, Carroll et al found that hospital admissions due to MI increased by 25% following the elimination of England from the 1998 World Cup.[10] Likewise, a Brazilian study published in 2013 demonstrated an increased incidence of MI during the World Cup soccer games that was slightly more pronounced when Brazil was playing.[21]

On the other hand, some studies have found no correlation between watching soccer and cardiovascular events. Barone-Adesi et al in 2010 looked at the incidence of hospital admissions for MI in Italy during the 2002 World Cup, 2004 European Championship, and 2006 World Cup. While similar in epidemiological data to many other studies, this study found no association between MI admissions and game days. Unlike Wilbert-Lampen et al, Barone-Adesi found no increased incidence of cardiac events even during intense games.[22] A study examining cardiovascular events in the Bavarian population by Niederseer et al yielded similar findings to this Italian study. Niederseer examined the incidence of MI, myocardial reinfarction, cardiac arrest, paroxysmal tachycardia, atrial fibrillation or flutter, and other tachyarrhythmias during the 2006 World Cup. This is a similar study design in many ways to that of Wilbert-Lampen, which studied the incidence of cardiovascular events in the greater Munich area—Munich being the capital of Bavaria. Conversely, Niederseer found that there was no association between increased cardiovascular events and spectatorships of the 2006 World Cup.[23]

With different study results, it is necessary to turn attention to the aggregate data to draw conclusions. A systematic review of the literature and meta-analysis by Wang et al in February 2020 included 19 cross-sectional observational studies and showed an increased risk of hospitalization and mortality related to cardiovascular events when watching major football tournaments. Additionally, the incidence of cardiovascular mortality was affected by the final results of the game; that is, the incidence became significantly higher in spectators of a team who lost the tournament (RR 1.19; 95% CI: 1.09-1.30), whereas the risk was lower in spectators of winner teams (RR 0.88; 95% CI: 0.79-0.98) both of which were statistically significant.[11] Lin et al found a similar association in their meta-analysis, specifically observing that the increased risk was more pronounced on male viewers.[24]

Different mechanisms have been proposed for the association between cardiovascular events and watching soccer matches. Wilbert-Lampen and

researchers conducted a physiological correlate study to their epidemiological one surrounding the 2006 World Cup. They discovered a positive correlation between endothelin-1 and "soccer-induced" elevated levels of sCD40L, sVCAM-1, MCP-1, and TNF-alpha.[25] Furthermore, an ECG based study of soccer fans during Germany's upsetting elimination from the 2018 World Cup revealed that such emotional stress could affect how the heart repolarizes—in other words, the heart's periodic repolarization dynamics.[26]

Baseball

The relationship between cardiovascular events and baseball spectatorship is a somewhat less examined phenomenon. One study in *The Journal of Clinical Hypertension* showed that baseball spectators had statistically significant drops in mean arterial pressure and diastolic blood pressure while viewing a game in comparison to their baseline values earlier on game day.[27] These physiologic endpoints, however, have rarely been correlated with actual clinical outcomes.

One of the few studies examining such clinical outcomes looked at the incidence of out-of-hospital cardiac arrests during the Japanese Professional Baseball Championship Series. The study purported a massive data set incorporating 666,020 out of hospital cardiac arrests between 2005 and 2014. According to the study, 12,809 of these cases occurred during the Japan Series, which only occupied 75 days out of the 9 years. This translated to an attributable risk of 3.19%. Specifically, the relative risk for having an out-of-hospital cardiac arrests on a Japan Series day was found to be statistically significant in males and individuals over 75 years of age. The relative risk values were modest (1.050 for men and 1.031 for those 75 years of age and older), but they were statistically significant unlike the relative risks calculated for females and other age groups.[28] In contrast to the blood pressure monitoring study previously mentioned, the Japan Series study did not look at actual physiologic parameters given its retrospective stratified case analysis design. The investigators did suggest plausible explanations for an increased relative risk in the elderly subgroup in that the plaques in these individuals may be more unstable and thus more susceptible to rupture. Ultimately, the study found that the risk of out of hospital cardiac arrest was 28.7% higher from 5 to 5:59 PM on days during the Japan Series compared to control days—corresponding to the time the games and media coverage began. These findings point to a relationship between viewership and cardiovascular events, although stronger causal or mechanistic relationships cannot be achieved.

Rugby

Rugby is often considered New Zealand's national sport. One study published in 2015 examined acute cardiac admissions during the Rugby World Cup (RWC) games in 1999, 2003, 2007, and 2011.[29] The study subdivided these admissions into 4 different classifications: acute coronary syndrome (MI or unstable angina), arrhythmias, heart failure, and stroke. The investigators used days in October or November of each year before the RWC tournament as controls—totaling 36 days of control data. The exposure data was then taken from admissions on the day of the match as well as 2 days after the game during the RWC. Interestingly, this study found a statistically significant difference in the number of heart failure admissions depending on whether the New Zealand team won or lost; the study specifically showed more heart failure admissions associated with the 2003 RWC loss by the New Zealand team than with control days. Moreover, in a separate study, the same investigators found that spectators demonstrated increased blood pressure and heart rate while watching the 2011 RWC final games compared to games in which the NZ team was not playing.[30] This is interesting to consider when heart rate and blood pressure can arguably be elevated while watching an intense match regardless of the outcome.

A 2020 study in *Physiology and Behavior* added another layer of complexity to the debate surrounding cardiovascular events and sports spectators. This study importantly reoriented the focus to the characteristics of the spectators rather than the cardiovascular outcomes. It compared recent and long retired rugby players' psychological and physiological responses to viewing a rugby game. The study demonstrated that recent retirees have less psychological stress before matches than long-term retired players, but that their vitals (including heart rate and blood pressure) were more elevated post-match compared to seasoned retirees. The study offered a possible explanation for this in their counterfactual thinking proposition; essentially, the psychological analysis aspect of the study found that recent-retired players may be viewing the match as a "challenge-oriented stressor" unlike long-retired players.[31] In that respect, it may not simply be a matter of viewership that can be correlated with cardiovascular events; how the spectator psychologically processes the match may impact the risk posed to the cardiovascular system.

Discussion

Previous studies of the relationship between sports spectatorship and cardiovascular events have drawn significant media attention and raised

public concern. To our knowledge, this review is the most comprehensive review of the literature pertaining to the topic of cardiovascular risk association with sports spectatorship. However, there is a relative paucity of information regarding this topic. General limitations of the studies covered in this analysis include: Sample size, participant characteristics, reporting bias, differing primary endpoints, numerous confounders, inconsistent metrics, lack of power. This review included studies related to cardiovascular events in spectators of soccer, football, hockey, rugby, and baseball. The review included: Seven soccer, two rugby, one football study, and two soccer meta-analysis. Perhaps unsurprisingly, given its global popularity, most literature to date centers around soccer, with only a few quality studies. While some studies have suggested a positive correlation between major sporting events and cardiovascular outcomes, others find no association.

Conclusion

The current literature surrounding adverse cardiovascular events among sports spectators shows increased cardiovascular mortality, particularly in fans of the defeated team and decreased in the victor's fans. Based on the current clinical evidence, it is better for one's cardiovascular health to participate in sporting activities as an athlete rather than as a fan, and "half-hearted" spectatorship may be better for cardiovascular health than fanatical spectatorship. Ironically, while aerobic exercise involved in most sports is generally considered a risk-reducing activity for athletes, the nonparticipating, sometimes fanatical spectators may not enjoy this cardiovascular benefit.

In conclusion, more research is needed to clarify the association between sports spectatorship and adverse cardiovascular events. The correlation between emotional stress and cardiovascular risk has widely been studied in the past years. As described, several studies have found an increased number of arrhythmogenic events, including fatal arrhythmias, chest pain, unstable angina, acute coronary syndrome, and sudden cardiac death in patients who are spectators of sporting events, especially in the setting of previously known coronary artery disease. There are well-described risk factors for atherosclerotic heart disease and the development of acute coronary syndromes; however, the role of inflammation, cytokine release, hematologic alterations, and immune-modulatory factors that maintain this atherosclerotic plaque intact is still controversial.

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