ORIGINAL ARTICLE

Cardiovascular Events during World Cup Soccer

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ABSTRACT

BACKGROUND

The Fédération Internationale de Football Association (FIFA) World Cup, held in Germany from June 9 to July 9, 2006, provided an opportunity to examine the relation between emotional stress and the incidence of cardiovascular events.

METHODS

Cardiovascular events occurring in patients in the greater Munich area were prospectively assessed by emergency physicians during the World Cup. We compared those events with events that occurred during the control period: May 1 to June 8 and July 10 to July 31, 2006, and May 1 to July 31 in 2003 and 2005.

RESULTS

Acute cardiovascular events were assessed in 4279 patients. On days of matches involving the German team, the incidence of cardiac emergencies was 2.66 times that during the control period (95% confidence interval [CI], 2.33 to 3.04; P<0.001); for men, the incidence was 3.26 times that during the control period (95% CI, 2.78 to 3.84; P<0.001), and for women, it was 1.82 times that during the control period (95% CI, 1.44 to 2.31; P<0.001). Among patients with coronary events on days when the German team played, the proportion with known coronary heart disease was 47.0%, as compared with 29.1% of patients with events during the control period. On those days, the highest average incidence of events was observed during the first 2 hours after the beginning of each match. A subanalysis of serious events during that period, as compared with the control period, showed an increase in the incidence of myocardial infarction with ST-segment elevation by a factor of 2.49 (95% CI, 1.47 to 4.23), of myocardial infarction without ST-segment elevation or unstable angina by a factor of 2.61 (95% CI, 2.22 to 3.08), and of cardiac arrhythmia causing major symptoms by a factor of 3.07 (95% CI, 2.32 to 4.06) (P<0.001 for all comparisons).

CONCLUSIONS

Viewing a stressful soccer match more than doubles the risk of an acute cardiovascular event. In view of this excess risk, particularly in men with known coronary heart disease, preventive measures are urgently needed.

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Events that induce environmental stress in a large number of people in defined areas — such as earthquakes, war, and sporting events — may increase the risk of cardiovascular events.[1-3] Reports of the association between soccer matches and rates of illness or death from cardiac causes have been controversial.[4-9]

The Fédération Internationale de Football Association (FIFA) World Cup was held in Germany from June 9 to July 9, 2006. It provided the opportunity to investigate the relation of emotional stress, experienced simultaneously in a predefined population during the soccer matches, and cardiovascular events, as prospectively assessed by experienced emergency medicine physicians. We hypothesized that in a country such as Germany — where soccer is particularly popular — World Cup matches involving the national team might be a trigger strong enough to cause an increase in the incidence of cardiac emergencies.

METHODS

ACQUISITION OF DATA

The study sites were all in Bavaria: emergency services in 15 locations, including the city of Munich, the conurbation of Munich, and a rural area, as well as 6 air rescue services and 3 intensive care vehicles. The prospectively assessed study period was June 9 to July 9, 2006. The periods of May 1 to July 31 in 2005 and in 2003, as well as May 1 to June 8 and July 10 to July 31, 2006, made up the control period. The year 2004 was excluded on the basis of possible effects of the European Soccer Championship in Portugal that year.

We studied patients who had contacted emergency services and had been treated by an emergency medicine physician and given one of the following final preclinical diagnoses: prolonged acute chest pain due to myocardial infarction with ST-segment elevation, myocardial infarction without ST-segment elevation or unstable angina, symptomatic cardiac arrhythmia, cardiac arrest leading to cardiopulmonary resuscitation, or therapeutic discharge of an implantable cardioverter–defibrillator. All patients included in the study were admitted to a hospital for further evaluation.

In order to rule out a possible increase in the incidence of cardiovascular events caused by shifts in population within the study area, we included only those patients who had had an event in their officially registered place of residence or within a 500-m radius of that residence. Thus, cardiac events were analyzed for local German residents only, not for visitors from inside or outside Germany.

We analyzed the emergency medicine doctors' records of the German Interdisciplinary Association for Intensive and Emergency Medicine (DIVI).[10] From the records, the following data were collected: date and location of the event, time of the emergency call, time of the onset of symptoms, details of the initial findings (i.e., blood pressure, heart rate, a brief medical history, and results on the electrocardiogram), the final diagnosis, and the patient's age and sex.

Weather data were obtained from Germany's national meteorologic service. Air-pollution data were collected from the Environmental Authority of the State of Bavaria.

The study protocol was approved by the ethics committee of the Medical Faculty of the Ludwig-Maximilians Universität and the Bavarian Medical Association. The requirement for informed consent was waived.

STATISTICAL ANALYSIS

We used Poisson regression with a log link to model the number of cardiovascular emergencies per day.[11] A day was defined as a 24-hour period beginning at noon. We compared events occurring during three different periods: the 7 days of World Cup matches played by the German team, the 24 days of the World Cup without German matches, and 242 control days (May 1 to June 8 and July 10 to July 31, 2006, and May 1 to July 31 in 2003 and 2005).

We calculated incidence ratios for the 7 days of matches played by the German team and the 24 days of matches not involving the German team as compared with the control period, using indicator variables. We then calculated incidence ratios for subgroups of patients, according to their region of residence or their final diagnosis, and compared them, assuming asymptotic normality of parameter estimates and independence of events between subgroups.

In order to avoid confounding, we included in our model the mean daily measurements for temperature, barometric pressure, and levels of particulate matter with a diameter smaller than 10 μm per cubic meter. All weather and air-pol-

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lution effects were checked for linearity with the use of quadratic and smooth functions.[12] By using forward selection with Akaike's information criterion (AIC)[12] for the control-period data, we included indicators for the year 2006 in our model, as well as for the days Tuesday, Saturday, and Sunday.

An autocorrelation plot of the Pearson residuals and a fitted quasi-Poisson regression analysis involving an additional overdispersion parameter clearly supported the assumptions of our model. Analyses were performed with the use of the glm and mgcv-gamm functions in the R software package.[13,14] A P value of less than 0.05 was considered to indicate statistical significance; all tests were two-sided.

RESULTS

A total of 4279 patients with acute cardiovascular events were included in the study. Figure 1 shows the numbers of cardiovascular events per day. The FIFA World Cup 2006 in Germany started on June 9, 2006, and ended on July 9, 2006. Six of the seven games in which the German team participated were associated with an increase in the number of cardiac emergencies over the number during the control period.

In a match on June 9, Germany beat Costa Rica (match 1 in Fig. 1); there was an increase in the number of cardiovascular events on this day as compared with the mean number during the control period. This effect was even more pronounced in the second preliminary match, when Germany beat Poland in a dramatic game, with the winning goal scored in the last minute (match 2). The increase in the number of events was less pronounced on the day of the match in which Germany beat Ecuador (match 3); Germany had already qualified for the next round.

The following matches were assumed to have provoked a very high level of emotional stress, because they were knockout games. On June 24, Germany beat Sweden (match 4 in Fig. 1); the increase in the number of cardiovascular events over that in the control period was pronounced. The quarterfinal on June 30 (match 5), in which Germany beat Argentina after a dramatic penalty shoot-out, was associated with a major increase in the number of events. On the day of the semifinal, in which Germany lost to Italy and failed to reach the final (match 6), the number of events

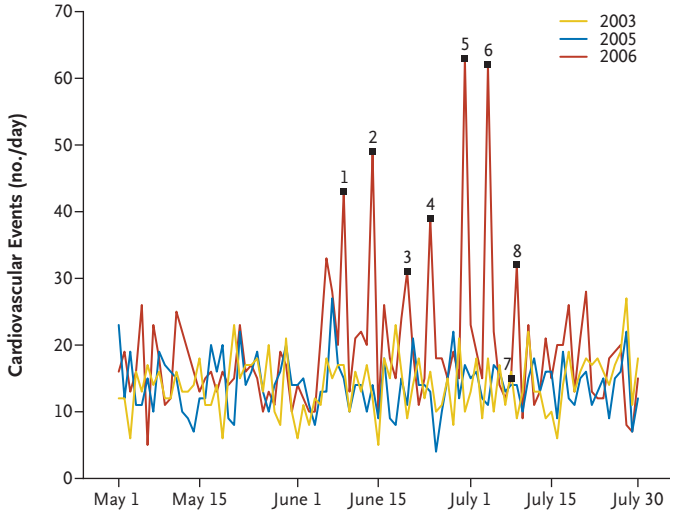


Figure 1. Daily Cardiovascular Events in the Study Population from May 1 to July 31 in 2003, 2005, and 2006.

The FIFA World Cup 2006 in Germany started on June 9, 2006, and ended on July 9, 2006. The 2006 World Cup matches with German participation are indicated by numbers 1 through 7: match 1, Germany versus Costa Rica; match 2, Germany versus Poland; match 3, Germany versus Ecuador; match 4, Germany versus Sweden; match 5, Germany versus Argentina; match 6, Germany versus Italy; and match 7, Germany versus Portugal (for third-place standing). Match 8 was the final match, Italy versus France.

increased roughly to the same extent as on the day of the match against Argentina. On the day of the match that determined third place, in which Germany beat Portugal (match 7), the number of events was not increased. The final match (match 8), Italy versus France, was again associated with a moderate increase in cardiac events.

Barometric pressure was positively associated with an increase in the number of cardiovascular events (incidence ratio, 1.12 per 10 hPa), as were the year 2006 (1.15), Tuesday (1.13), and Sunday (1.07); Saturday showed a negative association (0.78). Temperature (incidence ratio, 0.97 per 10°C) and particulate matter with a diameter smaller than 10 μm (1.01 per 10 μg per cubic meter) were forced a priori into the model, although no effect could be demonstrated during the study period. Consequently, the incidence ratios listed in Tables 1 and 2 were adjusted for all these covariables.

Table 1 shows the incidence ratios for cardiovascular events. After adjustment for covariates, the incidence during the matches involving the German team was 2.66 times that during the control period. No decrease in the number of

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Table 1. Incidence Ratios for Cardiovascular Events on Days during the World Cup, as Compared with Days during the Control Period, in the Overall Group and in Subgroups.*

Group	Total No. of Patients	Event during 7 Days of Matches Involving Germany (N=302)	Event during 24 Days of the World Cup without German Matches (N=436)	Event during 242 Days of the Control Period (N=3541)
Overall	4279			
No. of events per day		43.1	18.2	14.6
Incidence ratio (95% CI)		2.66 (2.33–3.04)	1.11 (0.99–1.25)	1.00
P value		<0.001	0.08	
City	2474			
Incidence ratio (95% CI)		2.63 (2.19–3.15)	1.17 (1.00–1.37)	1.00
P value		<0.001	0.04	
Suburb	503			
Incidence ratio (95% CI)		3.11 (2.15–4.48)	1.20 (0.86–1.66)	1.00
P value		<0.001	0.29	
Countryside	726			
Incidence ratio (95% CI)		1.99 (1.42–2.79)	0.93 (0.70–1.24)	1.00
P value		<0.001	0.63	
Interhospital transfer	576			
Incidence ratio (95% CI)		3.39 (2.45–4.69)	1.06 (0.77–1.45)	1.00
P value		<0.001	0.74	

* Incidence ratios were calculated as the mean number of cardiovascular events per day for days during the World Cup divided by the mean number per day for days during the control period. Data were adjusted for environmental and temporal variables.

cardiovascular events was observed during the hours or days after the games with German participation.

Analysis of the regional subgroups indicated a significant increase in the number of events during days on which Germany played in a match, as compared with the control period, for patients who lived in the city (incidence ratio, 2.63), those who lived in the suburbs (3.11), and those who lived in the countryside (1.99). The incidence of events that led to interhospital transfer for further evaluation increased as well (incidence ratio, 3.39). All effects were significant (P<0.001), although there were no significant differences among the incidence ratios between the regional subgroups (P=0.13). In contrast, we could not demonstrate a significant increase in the number of events on the 24 days of the World Cup without German participation.

Table 2 shows descriptive characteristics of patients who had a cardiovascular event, based on the history taken by the emergency medicine physician. During the 7 days of matches played by the German team, the proportion of patients who were men was much higher (71.5%) than during the control period (56.7%). For men, the incidence of cardiovascular events during the days of matches involving the German team was 3.26 times that in the control period; for women, the incidence was 1.82 times that in the control period; both effects were significant (P<0.001).

During the 7 days of matches played by the German team, as compared with the control period, patients tended to be younger (mean age, 65.4 vs. 68.5 years), the average heart rate and systolic blood pressure were slightly lower, and more patients had known coronary artery disease (47.0% vs. 29.1%). In order to assess the effect of stress in relation to the presence or absence of known coronary artery disease, we calculated the incidence ratios for patients with a history of coronary artery disease, and for those without, during the 7 days of matches played by the German team. The number of events in patients with known coronary artery disease increased by a factor of 4.03, and in those without known coro-

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Table 2. Characteristics of the Patients Who Had an Acute Cardiovascular Event on Days during the World Cup as Compared with Days during the Control Period.*

Characteristic	Total No. of Patients	Event during 7 Days of Matches Involving Germany (N=302)	Event during 24 Days of the World Cup without German Matches (N=436)	Event during 242 Days of the Control Period (N=3541)
Male sex	2490			
Percent of patients		71.5	61.0	56.7
Incidence ratio (95% CI)		3.26 (2.78–3.84)	1.16 (1.00–1.35)	1.00
P value		<0.001	0.05	
Female sex	1789			
Percent of patients		28.5	39.0	43.3
Incidence ratio (95% CI)		1.82 (1.44–2.31)	1.04 (0.87–1.44)	1.00
P value		<0.001	0.67	
Age — yr	4275	65.4±14.8	69.2±14.3	68.5±14.5
Heart rate — bpm	3537	87.0±32.5	92.0±35.2	92.9±36.9
Systolic blood pressure — mm Hg	4279	138.5±35.8	142.2±35.5	142.6±35.3
Known coronary artery disease	1319			
Percent of patients		47.0	33.9	29.1
Incidence ratio (95% CI)		4.03 (3.28–4.95)	1.17 (0.95–1.43)	1.00
P value		<0.001	0.13	
No known coronary artery disease	2960			
Incidence ratio (95% CI)		2.05 (1.72–2.44)	1.08 (0.94–1.25)	1.00
P value		<0.001	0.29	

* Plus–minus values are means ±SD. Incidence ratios were calculated as the mean number of cardiovascular events per day for days during the World Cup divided by the mean number per day for days during the control period. Data were adjusted for environmental and temporal variables.

nary artery disease by a factor of 2.05, as compared with the number of events during the control period. Both increases were significant (P<0.001). The difference between the incidence ratios of the two groups was also significant (P<0.001).

For prespecified subgroup analyses, we grouped the emergency medicine doctor's final diagnosis into four categories (Table 3). During the 7 days of games with German participation, there were 6.1 myocardial infarctions with ST-segment elevation per day, as compared with 2.6 per day during the control period, corresponding to an adjusted incidence ratio of 2.49. During the 7 days, the incidence ratio for chest pain, classified as myocardial infarction without ST-segment elevation or unstable angina, was 2.61; for the composite of cardiac arrhythmias causing major symptoms, the incidence ratio was 3.07, and for cardiac arrhythmias causing minor symptoms, it was 2.13. All increases were significant, but the effects were similar among the four diagnostic categories (P=0.62).

Figure 2 shows the numbers of events on days of German matches relative to the start of the game. There was a clear association between the start of the match and the onset of cardiac symptoms. The highest number of events was observed within the 2 hours after the start of the match, with numbers that were higher than the average (12.6 events) for several hours before and after the match.

DISCUSSION

Our results show a strong and significant increase in the incidence of cardiovascular events (including the acute coronary syndrome and symptomatic cardiac arrhythmia), in a defined sample of the German population, in association

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Table 3. Incidence Ratios for Cardiovascular Events on Days during the World Cup, as Compared with Days during the Control Period, According to the Final Diagnosis.*

Diagnostic Category	Event during 7 Days of Matches Involving Germany (N=302)	Event during 24 Days of the World Cup without German Matches (N=436)	Event during 242 Days of the Control Period (N=3541)
STEMI			
No. of patients	43	73	634
No. of events per day	6.1	3.0	2.6
Incidence ratio (95% CI)	2.49 (1.47–4.23)	1.09 (0.69–1.75)	1.00
P value	<0.001	0.71	
NSTEMI or unstable angina			
No. of patients	171	243	1873
No. of events per day	24.4	10.1	7.7
Incidence ratio (95% CI)	2.61 (2.22–3.08)	1.11 (0.96–1.28)	1.00
P value	<0.001	0.17	
Cardiac arrhythmia causing major symptoms			
No. of patients	71	89	767
No. of events per day	10.1	3.7	3.2
Incidence ratio (95% CI)	3.07 (2.32–4.06)	1.13 (0.87–1.47)	1.00
P value	<0.001	0.35	
Cardiac arrhythmia causing minor symptoms			
No. of patients	17	31	267
No. of events per day	2.4	1.3	1.1
Incidence ratio (95% CI)	2.13 (1.24–3.66)	1.10 (0.71–1.71)	1.00
P value	0.006	0.66	
Any category			
No. of patients	302	436	3541
No. of events per day	43.1	18.2	14.6

* Cardiac arrhythmias causing major symptoms were defined as those characterized by atrial fibrillation with rapid conduction (>100 beats per minute), ventricular tachycardia, cardiac arrest, or discharge of an implantable cardioverter–defibrillator. The composite of cardiac arrhythmias causing minor symptoms were defined as those characterized by sinus tachycardia, sinus bradycardia, atrial fibrillation with normal conduction, or premature beats. Incidence ratios were calculated as the mean number of cardiovascular events per day for days during the World Cup divided by the mean number per day for days during the control period. Data were adjusted for environmental and temporal variables. NSTEMI denotes myocardial infarction without ST-segment elevation, and STEMI myocardial infarction with ST-segment elevation.

with matches involving the German team during the FIFA World Cup held in Germany in 2006. In contrast, the average daily number of cardiac emergencies during soccer matches involving foreign teams was well within the range of values obtained during the control period. Since the incidence ratios were close to 1 for the days around the German matches, it is clear that watching an important soccer match, which can be associated with intense emotional stress, triggers the acute coronary syndrome and symptomatic cardiac arrhythmia.

An association between soccer matches and rates of illness or death from cardiovascular causes has been previously investigated in six retrospective epidemiologic studies.[4-9] Four assessed mortality due to myocardial infarction and stroke,[4,5,7,8] one assessed hospital admission due to myocardial infarction and stroke,[6] and the last involved a combined end point of cardiac and extracardiac diseases.[9] Data were collected by central bureaus for statistics. The results are inconsistent: two studies showed an increase in the relative risk of an event on the day of a

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match,[4,5] another showed an increase but did not evaluate it statistically,[6] two did not show an increase,[7,8] and one showed a decrease.[9] In contrast, the conceptual design of the present study was to prospectively evaluate clinical end points (myocardial infarction with ST-segment elevation, myocardial infarction without ST-segment elevation or unstable angina, and symptomatic cardiac arrhythmia) in a predefined population before, during, and after an entire soccer tournament, with assessments by a team of experienced emergency physicians. Using this study design, we found that the risk of an acute cardiovascular event on days on which matches were played by the German team was considerably increased overall, by a factor of 2.7; similar results were also found for all diagnostic subgroups.

Carroll et al.[6] found a significant increase in the incidence of acute myocardial infarction after the national team lost a penalty shoot-out, and we have documented an increase in the incidence of cardiac events after the German team won a penalty shoot-out. Apparently, of prime importance for triggering a stress-induced event is not the outcome of a game — a win or a loss — but rather the intense strain and excitement experienced during the viewing of a dramatic match, such as one with a penalty shoot-out.

Several studies have indicated that triggering is more common in patients with known coronary artery disease than in those without it.[1,15,16] Our results are consistent with these findings: cardiovascular events on days of soccer matches with German participation were associated with an increased rate of known coronary heart disease. More specifically, events occurred in all patients more frequently during the 7 days of matches played by the German team than during the control period, and the increase was greater among those with a history of coronary artery disease than among those without such a history (incidence ratio, 4.03 vs. 2.05). We assume that patients with preexisting coronary artery disease had, on average, more extensive underlying disease (more vulnerable plaques), leading to more frequent acute coronary syndromes, than did patients who were considered to be healthy before the event.

The emergency records enabled us to analyze the exact temporal relationship between the emotional trigger (the soccer match) and the onset of symptoms prompting the emergency call. Averaged over all seven games involving Germany, the incidence of events increased during the several hours before the match, the highest incidence was observed during the 2 hours after the start of the match, and the incidence remained increased for several hours after the end of the match. Trigger studies typically assess activities that are regarded as acute trigger mechanisms during the period of 1 or 2 hours before cardiac symptoms occur.[15,16] Thus, our findings with respect to the relationship between the timing of the trigger and the cardiovascular event fully concur with those in other trigger studies.

In accordance with other studies,[3-6] we found that most of the additional cardiac emergencies occurred in men. This phenomenon may be explained by sex-specific pathophysiological differences[17] or by differences in the degree of interest in soccer matches or vulnerability to emotional triggers.[18]

A trigger can be defined as a stimulus that produces pathophysiological changes leading directly to disease — in this case, cardiovascular diseases.[18] Although various mechanisms of stress-induced cardiac arrhythmias have been described,[19-21] those underlying the induction of acute coronary syndromes are less clear. As previously reported, stress hormones may directly influence endothelial and monocytic function.[22-24] Thus, future evaluations of endothelial and monocytic mediators in patients with stress-induced cardiovascular events might clarify the mechanisms of emotional triggering.

The excess risk of cardiovascular events associated with viewing stressful soccer matches (and probably other sporting events) is considerable, and evaluation of preventive measures is needed, particularly in patients with preexisting coronary artery disease. Interventions that might be considered include the administration or the increase in dose of beta-adrenergic-blocking drugs, anti-inflammatory agents such as statins, or antiplatelet drugs such as aspirin, as well as the blockade of stress-mediating receptors. In addition, nonmedical strategies, such as behavioral therapy for coping with stress, should be considered.

Our study has several limitations. The differentiation of myocardial infarction without ST-segment elevation from unstable angina was impossible because of the limited prehospital diagnosis. However, all patients with these diagnoses were

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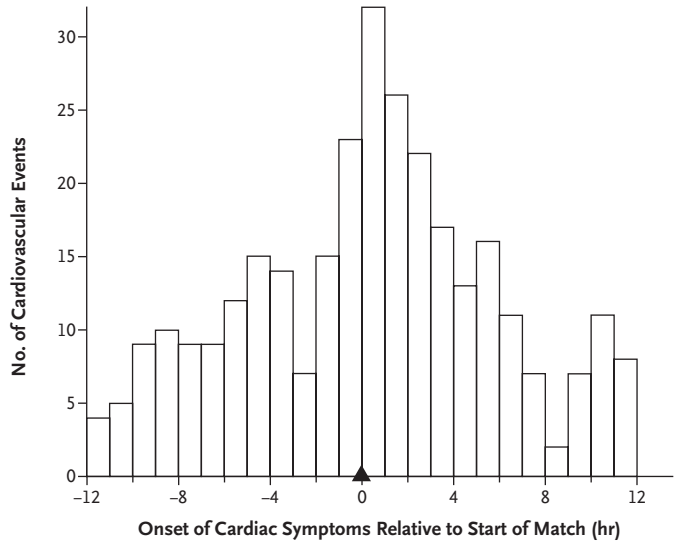


Figure 2. Daily Cardiovascular Events According to the Time of Onset of Symptoms before or after the Start of the Match.

The number of events was summed for all seven matches with German participation. The start of the match is represented by the black triangle.

found to require hospital admission for further evaluation. In addition, the rate of interhospital transport to specialized medical centers increased equally in all diagnostic subgroups, showing a high rate of serious cardiac events. We therefore believe that the increase in the incidence of myocardial infarction without ST-segment elevation or unstable angina reflected the induction of both conditions by stress, rather than emotionally induced, temporary episodes of angina. To confirm this, we would have to know the troponin levels.

Although the patients' conditions were evaluated by experienced emergency medicine physicians, some misclassifications might have occurred. However, this limitation is unlikely to have affected differently the 7 days of matches played by the German team, the 24 days of matches not involving the German team, and the control period.

Our results do not permit the identification of the exact triggers that provoked the additional cardiovascular events observed. Lack of sleep, overeating, consumption of junk food, heavy alcohol ingestion, smoking, and failure to comply with the medical regimen should all be considered.

In conclusion, we found a significant increase in the incidence of cardiovascular events (consisting of both the acute coronary syndrome and symptomatic cardiac arrhythmia), in a defined sample of the German population, in association with matches involving the German team during the FIFA World Cup, held in Germany in 2006. We hypothesize that these additional emergencies were triggered by emotional stress in relation to soccer matches involving the national team. Future studies are needed to assess stress triggering in association with other sporting events and to analyze the efficacy of medical treatment, nonmedical treatment, or both in reducing this stress-related excess risk of cardiovascular events.

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