Football spectatorship and selected acute cardiovascular events: lack of a population-scale association in Poland

Authors: Jenny E. Simon, Łukasz A. Małek, Andrzej Śliwczyński, Witold Śmigielski, Karol Korczak, Wojciech Drygas

Article type: Original article

Received: July 6, 2020.

Accepted: September 9, 2020.

Published online: September 21, 2020.

ISSN: 0022-9032

e-ISSN: 1897-4279

This is an Open Access article distributed under the terms of the Creative Commons Attribution-Non Commercial-No Derivatives 4.0 International License (CC BY-NC-ND 4.0), allowing third parties to download articles and share them with others, provided the original work is properly cited, not changed in any way, distributed under the same license, and used for noncommercial purposes only. For commercial use, please contact the journal office at kardiologiapolska@ptkardio.pl.
Football spectatorship and selected acute cardiovascular events: lack of a population-scale association in Poland

Jenny E. Simon¹, Łukasz A. Malek²*, Andrzej Śliwczyński³, Witold Śmigielski⁵, Karol Korczak⁶, Wojciech Drygas²,⁷

#both authors contributed equally to this work

¹Medical University of Warsaw, Warsaw, Poland
²Department of Epidemiology, Cardiovascular Disease Prevention and Health Promotion, National Institute of Cardiology, Warsaw, Poland
³University of Humanities and Economics in Łódź, satellite campus in Warsaw, Poland
⁴National Health Fund, Warsaw, Poland
⁵Department of Demography, University of Łódź, Łódź, Poland
⁶Department of Computer Science in Economics, University of Łódź, Łódź, Poland
⁷Department of Preventive and Social Medicine, Medical University of Łódź, Łódź, Poland

*Corresponding author:
Łukasz A. Malek, MD, PhD
tel./fax. + 48 22 815 65 56 ext. 214, e-mail: lmalek@ikard.pl
Department of Epidemiology, Cardiovascular Disease Prevention and Health Promotion, National Institute of Cardiology Niemodlińska str 33, 04-635 Warsaw, Poland

Conflict of interest: none

Funding: none

Short title: Football spectatorship and cardiovascular events

Key words: football, watching, acute myocardial infarction, sudden cardiac arrest, sudden arrhythmia
Abstract

**Background:** The status of football spectatorship-induced emotional stress as a risk factor for acute cardiovascular (CV) events remains in dispute.

**Aims:** To examine the relation between football spectatorship and the incidence of selected acute CV events across the Polish male population.

**Methods:** Events occurring in male patients aged 35 and older across Poland during three tournaments (the 2012 and 2016 European Championships - EC and the 2018 World Cup - WC) were retrospectively analysed through hospital admission codes obtained from the National Health Fund. Of interest were the following primary diagnoses: acute myocardial infarction (AMI, I21), sudden cardiac arrest (SCA, I46), sudden arrhythmias (SA, I47 - I49). The same dates in the years before and after the tournaments constituted the reference periods.

**Results:** A total of 255,383 patients were included in this study. There were no significant differences in the incidence of events between the combined exposure and reference periods: RR = 1.05 (95% CI 0.97 to 1.14, $P = 0.20$) for AMI, RR = 1.08 (95% CI 0.87 to 1.35, $P = 0.47$) for SCA, and RR = 1.02 (95% CI 0.98 to 1.06, $P = 0.32$) for SA. Individual tournament analyses revealed a higher incidence of AMI (RR = 1.20, 95% CI 1.12 – 1.30, $P < 0.001$) during WC. However, day-by-day analysis of WC did not find a higher incidence of AMI on match vs. match-free days.

**Conclusions:** The emotional stress evoked by football spectatorship is insufficiently potent to precipitate a population-scale increase in selected acute CV events.
What’s new?

This study is the first to analyse the relation between football spectatorship and acute cardiovascular (CV) events in Eastern Europe. It was based on the entire Polish male population aged 35 or older. We reported no evidence of increased rates of hospitalisation for acute myocardial infarction, sudden cardiac arrest, or sudden arrhythmias during three major football tournaments - 2012 and 2016 European Championships and 2018 World Cup - analysed together and separately. Similarly, day-by-day analysis found no evidence of increased risk of acute CV events associated with football matches played by the Polish national team during the 2018 World Cup. We conclude that the emotional stress evoked by football spectatorship in Poland is insufficiently potent to precipitate the onset of acute CV events on the population level. Our findings add to previous studies that shift the association between football spectatorship and the incidence of acute cardiovascular events towards the null hypothesis.

Introduction

As the leading cause of global mortality [1], cardiovascular (CV) diseases have been the object of countless preventive efforts. Among these has been the design to understand and neutralise the ‘triggers’ that precipitate acute cardiovascular events [2]. Long recognised triggers include episodes of emotional stress [3], strenuous physical exercise [4], and sexual activity [5]. Indeed, the empirical comorbidity of emotional stress and CV diseases was described as early as 1910, where the stress provoked by a ‘heated card game’ was said to directly precede myocardial infarction (MI) [6]. While estimates opine that triggers play a causative role in 20% of cases of acute coronary syndrome [7], retrospective studies reveal that as many as half of non-fatal CV disease patients self-report exposure to one or more
triggers [8, 9]. In regard to the triggering potential of emotional stress, there is an extensive body of evidence in support of an association between catastrophes - both man-made and not - and the incidence of adverse cardiac outcomes [10-14]. There is no reason to suppose that acute emotional stress is unique to these events, however, and several teams have extended the study to short-term stressors in the form of decisive sporting events.

Presently, the status of sports spectatorship as a risk factor for acute cardiovascular events is disputed [15-23]. Although this holds for a variety of team sports [24, 25], most studies have focused on football, whose emotional appeal is arguably unequalled among Europeans. In effect, where most studies report relative risk estimates spread around the null value [18]; 0.7 ≤ RR ≤ 1.3, a few report alarmingly high rates of cardiovascular events on days when football matches are contested [16, 19, 21, 23]. In a recent meta-analysis, Lin et al. concluded that viewing football matches is associated with a higher risk of fatal CV diseases and non-fatal MI in both men and women [26]. Particularly vulnerable to this phenomenon are men with known coronary heart disease [19]. Moreover, no significant increase in fatal or non-fatal cerebrovascular events were found. This corroborates the notion that stressful situations increase the incidence of stroke on a more chronic basis [27], in distinction to the acute stress response elicited by football spectatorship. Of note, the meta-analysis is limited in that it reports RR values for fatal CV diseases and non-fatal MI alone [26]. Finally, the impact of the outcome of a match on the incidence of CV diseases is most elusive of all [24].

To address the inconsistencies in the literature, we decided to perform a comprehensive analysis of selected acute cardiovascular events - acute myocardial infarction (AMI), sudden cardiac arrest (SCA), and sudden arrhythmias (SA) - and their association with three recent football tournaments across the entire Polish male population.
Materials and methods

Study periods

We studied weekly hospitalisations for selected acute CV events in the male Polish population during three tournaments; the 2012 UEFA European Championship (EC) held in Poland and Ukraine, the 2016 EC in France, and the 2018 FIFA World Cup (WC) in Russia. The following tournament dates constituted our exposure period: 1) for EC 2012 – May 28th to June 24th 2012, 2) for EC 2016 – May 30th to July 10th 2016 and 3) for WC 2018 – June 11th to July 8th 2018.

The weeks corresponding to tournament season in the odd-numbered years from 2011 through 2019 constituted our reference period. 2014 was excluded to avoid the extraneous influence of the WC that year, although the Polish national football team did not participate.

Study group

Records of hospital admissions were retrieved from the database of the Central Statistics Office (GUS) of the Polish National Health Fund (NFZ). Selected for the study were the data of all male patients - aged 35 and older - admitted to a hospital or ambulatory care centre in Poland during the exposure or reference periods with one of the following international disease classification (ICD-10) codes as primary diagnosis: I21, acute myocardial infarction (AMI); I46, sudden cardiac arrest (SCA); and I 47, paroxysmal tachycardia; I 48, atrial fibrillation, atrial flutter; I 49, i.e. all remaining tachyarrhythmias including ventricular tachycardia grouped together as sudden arrhythmias (SA). Besides primary diagnosis, the individual anonymous hospital admission forms disclosed age, gender, and date of admission. To circumvent the confounding variable posed by the day of the week [28, 29], we systematised the data on a weekly, rather than daily, basis. The number of events
was standardised per 100 000 persons of the male population.

Additionally, we collected data for outdoor temperature and air quality – assessed on the basis of nitric dioxide concentration (μg/m³) – in three regions of Poland (Gdańsk, Warsaw, and Wrocław) for the selected time periods. These were obtained from the Institute of Meteorology and Water Management, National Research Institute and the Chief Inspectorate for Environmental Protection, respectively.

Statistical analysis

Relative risk (RR) of hospitalisation for each of the aforementioned primary diagnoses during the tournament weeks (the exposure period) relative to the control weeks (the reference period) was computed with means of the algorithm described by Altman elsewhere [30]. We first determined the RRs for all tournaments relative to all reference periods combined. Subsequently, we analysed each tournament separately, and finally performed a detailed analysis of one tournament (WC 2018) on a day-by-day, per-match basis. Defined as ‘match days’ were the days a match was contested (Poland-Senegal, 19/06/2018; Poland-Colombia, 24/06/2018; and Poland-Japan, 28/06/2018), as well as the following day as events could have occurred past midnight. Comprising the ‘match-free days’ were the two days preceding the match day and the two days succeeding the day directly following the match day. All statistical calculations were performed using the MedCalc Software (Ostend, Belgium). The significance level was set at $P < 0.05$.

Ethical considerations

The study protocol is in compliance with the Declaration of Helsinki. Owing to its retrospective design, neither written nor verbal consent was required of the patients for this particular study. However, each subject had signed a consent form for medical treatment,
including a statement of agreement to the use of data for scientific purposes.

**Results**

A total of 255 383 patients were included in this study, having satisfied all selection criteria, namely; male gender, aged 35 or older, and admitted to a hospital or ambulatory care centre in Poland for I21 (45,164), I46 (6,068), or I47 - I49 (204,151) during either of the aforedefined exposure or reference periods. In line with our method, we report the results of our analysis in a step-wise manner, starting with a comparison of the three tournament years combined relative to all five reference years combined. This is followed by an individual analysis of each of the three tournaments, relative to the two neighbouring odd-numbered and tournament-free years. Finally, we focus our attention on the most recent tournament – the 2018 WC – by comparing match days to non-match days.

**Combined analysis**

A mean of 65.49 acute cardiovascular events (12.10 cases of I21, 1.64 of I46, and 51.75 of I47 - I49) per week per 100 000 men were reported during the exposure period, in close parallel to the mean of 63.76 events (11.49 cases of I21, 1.51 of I46, and 50.76 of I47 - I49) observed during the reference period.

No significant differences were found in the incidences of acute cardiovascular events between the exposure and reference periods, with relative risk values consistently surrounding the null value: RR = 1.05 (95% CI 0.97 to 1.14, \( P = 0.20 \)) for AMI, RR = 1.08 (95% CI 0.87 to 1.35, \( P = 0.47 \)) for SCA, and RR = 1.02 (95% CI 0.98 to 1.06, \( P = 0.32 \)) for SA. The results of the combined analysis are presented in Table 1. The results were consistent among all age groups.
**Individual tournaments**

Events during the individual tournaments relative to their respective reference periods (the corresponding dates in the years before and after) are presented in Table 2 and in Supplementary Tables S1 and S2. Neither EC tournament was associated with a significant difference in the frequency of AMI or SCA among Polish men. More inconsistent was the association between football spectatorship and SA, with small yet statistically significant increases (RR = 1.05, 95% CI 1.01 – 1.08, \( P = 0.02 \)) and decreases (RR=0.95, 95% CI 0.91 – 0.99, \( P = 0.02 \)) in its incidence during the 2016 and 2012 EC tournaments, respectively.

For the 2018 WC, we report a higher incidence of AMI (RR = 1.20, 95% CI 1.12 – 1.30, \( P < 0.001 \)). This was mainly driven by the higher rate of hospitalisation for AMI in men aged 50 – 79 during the tournament period. Meanwhile, no differences in the incidence of SCA or SA were found during this tournament, relative to its reference periods in 2017 and 2019.

**Per-match day analysis**

Finally, we report the results of a day-by-day analysis for the 2018 WC (Table 3). Despite a highly significant increase in the incidence of AMI over the whole WC tournament, no statistically significant differences were found in the incidence of AMI, SCA, or SA between match and match-free days.

The outdoor temperature and air pollution data are presented in Table 4.
Discussion

The mechanistic basis coupling emotional stress to the onset of CV diseases is twofold. Firstly, behavioural mechanisms are at play, as emotional stress impairs health decision-making. Consequently, behaviours such as smoking, binge drinking, poor dietary compliance, physical inactivity, and poor adherence to medical regimen stand in lieu of health-promoting behaviours [31]. Secondly, direct pathophysiological mechanisms, though incompletely understood, can be cogently assembled as follows: emotional stress stimulates the sympathetic nervous system, which results in increased heart rate, blood pressure, and cardiac contractility, thereby raising the myocardial oxygen demand [32]. Compounded by a concomitant increase in coronary vascular tone and failure of the coronary microvasculature to dilate, myocardial perfusion is impaired. Collectively, these events promote myocardial ischaemia and atherosclerotic plaque rupture. Besides changes in sympathetic tone, emotional stress generates an increase in circulating catecholamines, which reduce myocardial electrical stability and thus expedite arrhythmogenesis [33, 34]. Stress hormones may also directly alter endothelial and monocytic function [19, 35]. Lastly, prothrombotic changes in the haemostatic system and haematologic indices are observed, namely: increased markers of procoagulant activity [36], increased platelet aggregability, decreased fibrinolytic activity [7, 37], and increased haematocrit [38] and blood viscosity [39]. Interestingly, a recent study found that cardiovascular diseases were a more common cause of death among elite Polish footballers than in the general male population [40].

As holds for many other European nations, football is the most popular sport in Poland. In addition, the FIFA World Cup - a quadrennial football tournament organised by the sport’s global governing body - is the biggest single-sport international sporting event to exist. Like the WC, the UEFA European Championship is a major quadrennial international
football tournament. According to Nielsen Audience Measurements, the average number of spectators in Poland for the analysed tournaments approximated 4 million people, with around 30 million people watching at least one minute of a game during one tournament. Matches of the Polish national football team drew most attention and were watched by approximately 8 to 17 million spectators on television, depending mainly on the importance of the game: 8 million watched the Poland-Japan match during the already-lost 2018 WC in comparison to the 17 million that watched the Poland-Portugal quarterfinal during the 2016 EC, which was the highest achievement of the Polish national team during the analysed tournaments. In two of the three analysed tournaments - during the 2012 EC co-hosted with Ukraine and during the 2018 WC - the Polish national team was eliminated in the group phase, while it made it to the quarterfinals during the 2016 EC. However, expectations were high during all three tournaments, owing both to abundant press coverage and success in the elimination phases.

Our combined analysis found no evidence of increased rates of hospitalisation for AMI, SCA, or SA associated with the three football tournaments. Similarly, day-by-day analysis of the 2018 WC found no evidence of increased risk of AMI, SCA, or SA associated with football matches played by the Polish national team. The only outstanding results were: a) the fluctuating differences in the incidence of SA during the two EC tournaments, which could thus be regarded as a chance finding, and b) the higher incidence of AMI during the 2018 WC, which warrants further discussion, especially in light of the negative findings reported for the day-by-day analysis of the same tournament. We posit that the higher incidence of AMI during the 2018 WC must have been provoked by factors other than match spectatorship, as the most decisive, high-stake games of the Polish national team had already been contested and lost without producing an increase in the rate of AMI admissions. This postulate is founded on studies that have shown that the outcome of a game may impact the
frequency of acute cardiovascular events, with lost games posing the highest risk [16,23,26]. Though we cannot uniformly determine which factors were in play, weather analyses revealed that outdoor temperatures were much higher in 2018 and 2019 than in 2017, which could have influenced the results as 2017 was part of the reference period [41]. In effect, after removal of 2017 from the reference period the results became insignificant (data not shown). Recognition of other potential causes of acute events would require an extensive clinical assessment [42].

Our study is the first of its kind performed in East-Central Europe. The estimates are based on a very large study group; comprising the whole male population of Poland over 35 years old (over 10 million people), included football events distributed over a period of seven years, and have been checked for weather condition linearity. Unlike many previous studies limited to selected events, we included a broad spectrum of cardiovascular diagnoses [18, 26]. Of note, almost all studies, which reported a significant association between football spectatorship and acute CV diseases, responsible for shifting the association found in the meta-analysis towards significance, were based on selected populations such as provinces of Switzerland or regions of Bavaria and on single events. Meanwhile, broader, nation-wide analyses and/or analyses of more tournaments, like ours, consistently demonstrated the lack of a significant association [26]. Furthermore, some studies did not include the days of the week as a potential confounder by systemizing data on a weekly rather than tournament period basis [17,19]. In our study (like in other studies [28,29]) a peak of hospital admissions due to acute CV events occurred through Mondays to Wednesdays, which if not adjusted for, could influence the results (Supplementary Figure S1).

Of course, while no association was detected at the population level, our results cannot eliminate the possibility of individual football spectatorship-induced cardiovascular events. Our findings should also be considered in view of potential regional and social
differences in the emotional engagement elicited by football spectatorship. Furthermore, the Polish national team has failed qualifier games and lost early matches for many consecutive tournaments since the time of its peak performance (during the 1974 and 1982 WCs, winning bronze medals). This might have been accompanied by changes in spectator attitudes that curtailed emotional engagement. It is also possible that, unlike in other regions of the world or in selected environments, football spectatorship is not conducive to emotional responses robust enough to trigger or precipitate acute CV events on the population level in Poland [16,43].

Our study was limited to the male population of Poland, although it may be expected that the emotional stress accompanying football spectatorship is greater in men than in women. Therefore, if no consistent significant differences were found in men, it is unlikely such differences would exist among the female Polish population. Another limitation is the use of hospital admission codes, which may include cases of underreporting or misreporting and our study may thus include a fraction of misclassified patients.

In conclusion, we posit that the emotional stress evoked by football spectatorship is insufficiently potent to precipitate the onset of selected acute CV events on the population level. Our findings add to previous studies that shift the association between football spectatorship and the incidence of acute cardiovascular events towards the null hypothesis.
References:

1. Mensah GA, Roth GA, Fuster V. The Global Burden of Cardiovascular Diseases and Risk Factors. J Am Coll Cardiol. 2019; 74: 2529–2532.

2. Tofler GH, Muller JE. Triggering of Acute Cardiovascular Disease and Potential Preventive Strategies. Circulation. 2006; 114: 1863–1872.

3. Dimsdale JE. Psychological Stress and Cardiovascular Disease. J Am Coll Cardiol. 2008; 51: 1237–1246.

4. Mittleman MA, Maclure M, Tofler GH, et al. Triggering of Acute Myocardial Infarction by Heavy Physical Exertion - Protection against Triggering by Regular Exertion. N Engl J Med. 1993; 329: 1677–1683.

5. Moller J. Sexual activity as a trigger of myocardial infarction. A case-crossover analysis in the Stockholm Heart Epidemiology Programme (SHEEP). Heart. 2001; 86: 387–390.

6. Obrastzo VP, Strazhesko ND. The symptomatology and diagnosis of coronary thrombosis. In: Vorobeva VA, Konchalovski MP, editors. Works of the first congress of Russian therapists. Comradeship typography of AE Mamontov; 1910, 26-43.

7. Willich SN. Circadian variation and triggering of cardiovascular events. Vasc Med. 1999; 4: 41–49.

8. Tofler GH, Stone PH, Maclure M, et al. Analysis of possible triggers of acute myocardial infarction (the MILIS study). Am J Cardiol. 1990; 66: 22–27.

9. Behar S, Halabi M, Reicher-Reiss H, et al. Circadian variation and possible external triggers of onset of myocardial infarction. Am J Med. 1993; 94: 395–400.

10. Meisel SR, Dayan KI, Pauzner H, et al. Effect of Iraqi missile war on incidence of acute myocardial infarction and sudden death in Israeli civilians. Lancet. 1991; 338: 660–661.
11. Rumboldt Z, Miric D, Bozic I, et al. War-stress-induced medical emergencies in south Croatia. Lancet. 1993; 341: 965–966.

12. Aoki T, Fukumoto Y, Yasuda S, et al. The Great East Japan Earthquake Disaster and cardiovascular diseases. Eur Heart J. 2012; 33: 2796–2803.

13. Leor J, Poole WK, Kloner RA. Sudden Cardiac Death Triggered by an Earthquake. N Engl J Med. 1996; 334: 413–419.

14. Leor J, Kloner RA. The Northridge earthquake as a trigger for acute myocardial infarction. Am J Cardiol. 1996; 77: 1230–1232.

15. Niederseer D, Thaler CW, Egger A, et al. Watching soccer is not associated with an increase in cardiac events. Int J Cardiol. 2013; 170: 189–194.

16. Kirkup W, Merrick DW. A matter of life and death: population mortality and football results. J Epidemiol Community Health. 2003; 57: 429–432.

17. Katz E, Metzger J-T, Marazzi A, et al. Increase of sudden cardiac deaths in Switzerland during the 2002 FIFA World Cup. Int J Cardiol. 2006; 107: 132–133.

18. Barone-Adesi F, Vizzini L, Merletti F, et al. It is just a game: lack of association between watching football matches and the risk of acute cardiovascular events. Int J Epidemiol. 2010; 39: 1006–1013.

19. Wilbert-Lampen U, Leistner D, Greven S, et al. Cardiovascular Events during World Cup Soccer. N Engl J Med. 2008; 358: 475–483.

20. Jauss M, Sitzer M, Stolz E, et al. Lack of increase of cerebrovascular events during German World Cup soccer games in 2006. J Neurol. 2009; 256: 863–866.

21. Carroll D. Admissions for myocardial infarction and World Cup football: database survey. BMJ. 2002; 325: 1439–1442.

22. Berthier F. Lower myocardial infarction mortality in French men the day France won the 1998 World Cup of football. Heart. 2003; 89: 555–556.
23. Witte DR, Bots ML, Hoes AW, et al. Cardiovascular mortality in Dutch men during 1996 European football championship: longitudinal population study. BMJ. 2000; 321:1552–1554.

24. Zimmerman FH, Fass AE, Katz DR, et al. Safety of Spectator Sports: Blood Pressure and Heart Rate Responses in Baseball and Football Fans. Am J Hypertens. 2010; 12: 816–817.

25. Kloner RA, McDonald S, Leeka J, et al. Comparison of Total and Cardiovascular Death Rates in the Same City During a Losing Versus Winning Super Bowl Championship. Am J Cardiol. 2009; 103: 1647–1650.

26. Lin L-L, Gu H-Y, Yao Y-Y, et al. The association between watching football matches and the risk of cardiovascular events: A meta-analysis. J Sport Sci. 2019; 37: 2826–2834.

27. May M, McCarron P, Stansfeld S, et al. Does Psychological Distress Predict the Risk of Ischemic Stroke and Transient Ischemic Attack? Stroke. 2002; 33: 7–12.

28. Turin TC, Kita Y, Rumana N, et al. Incidence, admission and case-fatality of acute myocardial infarction: weekend versus weekday in a Japanese population: 16-year results from Takashima AMI Registry (1988–2003). Eur J Epidemiol. 2008; 24: 93–100.

29. Barnett AG. Excess in cardiovascular events on Mondays: a meta-analysis and prospective study. J Epidemiol Community Health. 2005; 59: 109–114.

30. Altman DG ed. Practical statistics for medical research. London: Chapman and Hall; 1991

31. Ferrer RA, Mendes WB. Emotion, health decision making, and health behaviour. Psychol Health. 2017; 33: 1–16.

32. Chi JS. Stress and myocardial infarction. Heart. 2003; 89: 475–476.

33. Lown B, Verrier R, Corbalan R. Psychologic Stress and Threshold for Repetitive Ventricular Response. Science. 1973; 182: 834–836.
34. Brodsky MA. Ventricular Tachyarrhythmia Associated with Psychological Stress. JAMA 1987; 257: 2064-2067.

35. Wilbert-Lampen U, Trapp A, Modzik M, et al. Effects of corticotropin-releasing hormone (CRH) on endothelin-1 and NO release, mediated by CRH receptor subtype R2: A potential link between stress and endothelial dysfunction? J Psychosom Res. 2006; 61: 453–460.

36. Matsuo T, Suzuki S, Kodama K, et al. Hemostatic activation and cardiac events after the 1995 Hanshin-Awaji earthquake. Int J Hematol. 1998; 67: 123-129.

37. von Känel R, Mills PJ, Fainman C, et al. Effects of Psychological Stress and Psychiatric Disorders on Blood Coagulation and Fibrinolysis: A Biobehavioral Pathway to Coronary Artery Disease? Psychosom Med. 2001; 63: 531–544.

38. Patterson SM, Krantz DS, Gottdiener JS, et al. Prothrombotic Effects of Environmental Stress. Psychosom Med. 1995; 57: 592–599.

39. Lowe GDO, Lee AJ, Rumley A, et al. Blood viscosity and risk of cardiovascular events: The Edinburgh Artery Study. Br J Haematol. 1997; 96: 168–173.

40. Gajda J, Śmigielski W, Śmigielski J, et al. Longevity and cardiovascular mortality of Polish elite football players. Kardiol Pol. 2018; 76: 1705-1711.

41. Sun Z, Chen C, Xu D, et al. Effects of ambient temperature on myocardial infarction: A systematic review and meta-analysis. Environ Pollut. 2018; 241: 1106-1114.

42. Stępień-Wojno M, Ponińska J, Rydzanicz M, et al. Sudden cardiac arrest in patients without overt heart disease: a limited value of next generation sequencing. Pol Arch Intern Med. 2018; 128: 721-730.

43. Borges DG, Monteiro RA, Schmidt A, et al. World soccer cup as a trigger of cardiovascular events. Arq Bras Cardiol. 2013; 100: 546-552.
**Table 1.** Frequency of selected acute cardiovascular events per 100 000 men in Poland in the tournament (exposure period) and tournament-free years (reference period).

| Diagnosis                  | Age group | Tournament-free (reference) years | Tournament (exposure) years | Relative Risk (95% CI) | P value |
|----------------------------|-----------|-----------------------------------|----------------------------|------------------------|---------|
| Acute Myocardial Infarction| 35 - 49   | 2.59                              | 2.61                       | 1.01 (0.77 – 1.32)     | 0.95    |
|                            | 50 - 64   | 12.94                             | 13.78                      | 1.06 (0.94 – 1.20)     | 0.33    |
|                            | 65 - 79   | 23.57                             | 24.81                      | 1.05 (0.92 – 1.20)     | 0.45    |
|                            | 80+       | 29.31                             | 29.95                      | 1.02 (0.81 – 1.29)     | 0.83    |
| Diagnosis       | Age group | Tournament-free (reference) years | Tournament (exposure) years | Relative risk (RR, 95% CI) | P value |
|-----------------|-----------|----------------------------------|-----------------------------|---------------------------|---------|
| Acute Myocardial Infarction | 35 - 49   | 2.65                             | 2.66                        | 1.01 (0.77 – 1.32)        | 0.94    |
|                 | 50 - 64   | 12.37                            | 12.50                       | 1.01 (0.89 – 1.14)        | 0.87    |
|                 | 65 - 79   | 23.67                            | 24.21                       | 1.02 (0.89 – 1.18)        | 0.73    |
|                 | 80+       | 30.27                            | 31.26                       | 1.03 (0.81 – 1.31)        | 0.79    |
|                 | 35+       | 11/21                            | 11.40                       | 1.02 (0.94 – 1.10)        | 0.70    |
| Sudden Cardiac Arrest | 35 - 49   | 0.37                             | 0.36                        | 0.93 (0.45 – 1.93)        | 0.85    |

Table 2. Frequency of selected acute cardiovascular events per 100 000 men in Poland during the 2012 European Championships and neighboring tournament-free years (2011, 2013).
Table 3. Frequency of selected acute cardiovascular events per 100 000 men in Poland during the 2018 World Cup during Polish National Team match days and days after vs. days before and after games.

| Game | Diagnosis            | Age / Period | Days before and after games | Match day and day after | Relative risk (95% Cl) | P value |
|------|----------------------|--------------|-----------------------------|-------------------------|------------------------|---------|
| 19.06.2018. Poland - Senegal 1:2 | Acute Myocardial Infarction | 35 - 49 | 27 | 22 | 0.81 (0.46 - 1.43) | 0.48 |
|      |                      | 50 - 64 | 113 | 113 | 1.00 (0.77 - 1.30) | 1.00 |
|      |                      | 65 - 79 | 114 | 109 | 0.96 (0.74 - 1.24) | 0.74 |
|      |                      | 80+     | 26  | 27  | 1.04 (0.61 - 1.78) | 0.89 |
|      |                      | 35+     | 281 | 271 | 0.96 (0.82 - 1.14) | 0.67 |
|      | Sudden Cardiac Arrest | 35 - 49 | 1  | 3  | 3.00 (0.31 - 28.84) | 0.34 |
|      |                      | 50 - 64 | 9  | 8  | 0.89 (0.34 - 2.30) | 0.81 |
| Age Group | Sudden Arrhythmias | Acute Myocardial Infarction | Sudden Cardiac Arrest | Sudden Arrhythmias |
|-----------|--------------------|-----------------------------|----------------------|-------------------|
| 65 - 79   |                    |                             |                      |                   |
| 80+       | 11                 | 9                           | 0.82 (0.34 - 1.97)   | 0.66              |
| 35+       | 26                 | 25                          | 0.96 (0.56 - 1.66)   | 0.89              |
| 35 - 49   |                    |                             |                      |                   |
| 50 - 64   | 65                 | 65                          | 1.00 (0.71 - 1.41)   | 1.00              |
| 65 - 79   | 638                | 641                         | 1.00 (0.90 - 1.12)   | 0.93              |
| 80+       | 237                | 226                         | 0.95 (0.79 - 1.14)   | 0.61              |
| 35+       | 1264               | 1239                        | 0.98 (0.91 - 1.06)   | 0.62              |
| 35+       | 19                 | 23                          | 1.21 (0.66 - 2.22)   | 0.54              |
| 35 - 49   |                    |                             |                      |                   |
| 50 - 64   | 95                 | 97                          | 1.02 (0.77 - 1.35)   | 0.89              |
| 65 - 79   | 86                 | 89                          | 1.03 (0.77 - 1.39)   | 0.82              |
| 80+       | 26                 | 21                          | 0.81 (0.45 - 1.44)   | 0.47              |
| 35+       | 230                | 225                         | 0.98 (0.81 - 1.18)   | 0.81              |
| 35 - 49   |                    |                             |                      |                   |
| 50 - 64   | 4                  | 4                           | 1.00 (0.25 - 4.00)   | 1.00              |
| 65 - 79   | 11                 | 14                          | 1.27 (0.58 - 2.80)   | 0.55              |
| 80+       | 6                  | 2                           | 0.33 (0.07 - 1.65)   | 0.18              |
| 35+       | 30                 | 31                          | 1.03 (0.63 - 1.71)   | 0.90              |
| 35 - 49   |                    |                             |                      |                   |
| 50 - 64   | 41                 | 43                          | 1.05 (0.68 - 1.61)   | 0.83              |
| 65 - 79   | 178                | 181                         | 1.02 (0.83 - 1.25)   | 0.87              |
| 80+       | 326                | 331                         | 1.02 (0.87 - 1.18)   | 0.84              |
| 35+       | 112                | 111                         | 0.99 (0.76 - 1.29)   | 0.95              |
| 35 - 49   |                    |                             |                      |                   |
| 50 - 64   |                    |                             |                      |                   |
| 65 - 79   |                    |                             |                      |                   |
| 80+       |                    |                             |                      |                   |
| 35+       |                    |                             |                      |                   |

24.06.2018, Poland - Colombia 0:3
| Year               | 2011 (European Championship) | 2012 (European Championships) | 2013 | 2015 | 2016 (European Championships) | 2017 | 2018 (World Cup) | 2019 |
|-------------------|-------------------------------|--------------------------------|------|------|-------------------------------|------|------------------|------|
| 28.06.2018. Poland - Japan 1:0 | Acute | 35 - 49 | 24 | 28 | 1.17 (0.68 - 2.01) | 0.58 |
|                   | Myocardial Infarction | 50 - 64 | 112 | 113 | 1.01 (0.78 - 1.31) | 0.95 |
|                   |                | 65 - 79 | 101 | 103 | 1.02 (0.78 - 1.34) | 0.89 |
|                   |                | 80+ | 27 | 27 | 1.00 (0.59 - 1.70) | 1.00 |
|                   |                | 35+ | 264 | 271 | 1.03 (0.87 - 1.22) | 0.76 |
|                   | Sudden Cardiac Arrest | 35 - 49 | 3 | 1 | 0.33 (0.03 - 3.20) | 0.34 |
|                   |                | 50 - 64 | 11 | 7 | 0.64 (0.25 - 1.64) | 0.35 |
|                   |                | 65 - 79 | 9 | 9 | 1.00 (0.40 - 2.52) | 1.00 |
|                   |                | 80+ | 7 | 6 | 0.86 (0.29 - 2.55) | 0.78 |
|                   |                | 35+ | 30 | 23 | 0.77 (0.45 - 1.32) | 0.34 |
|                   | Sudden Arrhythmias | 35 - 49 | 56 | 44 | 0.79 (0.53 - 1.17) | 0.23 |
|                   |                | 50 - 64 | 249 | 251 | 1.01 (0.85 - 1.20) | 0.93 |
|                   |                | 65 - 79 | 498 | 472 | 0.95 (0.84 - 1.07) | 0.40 |
|                   |                | 80+ | 172 | 175 | 1.02 (0.82 - 1.26) | 0.87 |
|                   |                | 35+ | 975 | 941 | 0.97 (0.88 - 1.06) | 0.44 |

**Table 4.** Average outdoor temperature and air pollution during in the tournament periods (exposure period) and tournament-free years (reference period).
|                                | s     |
|--------------------------------|-------|
| **Outdoor temperature, °C**    |       |
| (standard deviation)           | (      |
| 18.2 (2.1)                     | 17.7  (2.0) |
| 17.7 (1.9)                     | 18.0 (2.2) |
| 19.0 (2.7)                     | 18.1 (2.2) |
| 19.8 (3.0)                     | 20.3 (3.1) |
| **Nitric dioxide μg/m³**       |       |
| (standard deviation)           | (      |
| 12.2 (3.2)                     | 10.4  (2.5) |
| 11.3 (2.8)                     | 10.1 (1.4) |
| 15.8 (3.8)                     | 11.4 (3.2) |
| 12.6 (3.9)                     | 9.9  (2.7) |