

Autonomic stress responses elicited by watching a live broadcast soccer game:

A pilot study

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Summary

AIM OF THE STUDY: Increased rates of hospitalization due to cardiovascular events have been reported during phases of World Soccer Championships (WSC). The purpose of this pilot study was to explore acute psychological and physiological effects of watching a live broadcast soccer game during the WSC 2006.

METHODS: Seven male supporters (age: $M = 24$; $SD = 2.7$) of the Swiss National Soccer Team watched a game of their team in a controlled laboratory setting. Heart rate (HR), heart rate variability (HRV), salivary cortisol, alpha-amylase (sAA), and testosterone concentrations, as well as several mood ratings were captured repeatedly before, during, and after the game.

RESULTS: Subjects reported feeling stressed, and HR and sAA activity showed an increase during the game. In contrast, HRV, cortisol and testosterone were unaffected.

CONCLUSIONS: Watching a sports competition seems to specifically affect the sympathetic nervous system, which can be measured by sensitive electrocardiographic and salivary markers.

Keywords: stress, cortisol, alpha-amylase, heart rate, heart rate variability, watching sports competitions

Introduction

While the psychological and physiological effects of playing soccer are fairly well understood, information on the effects of watching soccer is largely deduced from epidemiologic studies, which report inconsistent findings. Some studies revealed increases in myocardial infarctions during phases of championship tournaments^{1,2} or after single games^{3,4}, suggesting sport events to be a potential risk factor. Other authors did not find this pattern⁵ or observed a decrease in deadly myocardial infarction after won games⁶. This leads to considerations about scoring-dependent reactions^{5,7} and salutogenic effects of vicarious wins⁶. More concrete support for the effects on spectators' autonomic nervous system (ANS) has been derived from direct observations of sports events affecting cardiovascular activity in healthy subjects and cardiac patients⁸⁻¹². With regard to the occasion of a soccer game, no data have yet been presented for heart rate variability (HRV) and salivary alpha-amylase (sAA), two further indicators of the ANS which have been repeatedly reported to alter in response to stressful stimuli¹³⁻¹⁷. High frequency power (HF) of HRV has been shown to indicate parasympathetic activation¹⁸, low frequency power (LF) has been proposed to reflect both parasympathetic and sympathetic activation^{16,18}, and the ratio between LF and HF (LF/HF ratio) has been suggested to mirror sympathovagal balance¹⁹. sAA has been shown to increase with sympathetic activation and was proposed to be an even more sensitive indicator of stress than blood pressure or HR²⁰. Several studies have been conducted to investigate the effects of attending sports events on cortisol. Cortisol is an endocrine indicator of the hypothalamic-pituitary-adrenal (HPA) axis and shows high reactivity to subjectively experienced stress²¹. Some studies on the cortisol response to attending sport events reported reductions or no alterations in cortisol^{22,23}, while one study reported an increase in cortisol among soccer coaches²⁴.

The purpose of the present study was to explore the physiological stress responses of watching a live televised soccer game. We expected to find stress-specific alterations for the markers of the ANS.

Method

Participants and Procedure

Seven healthy male Caucasian students aged 21 to 29 ($M = 24$; $SD = 2.7$) agreed to participate in the study. Inclusion criteria were male sex and an age between 20 and 30 years, while exclusion criteria were smoking, self-reported acute or chronic mental or somatic disorders, and medication. Participants were recruited through flyers posted at the Universities of Zurich. All participants stated that they were fans of the Swiss National Soccer Team. They were advised to refrain from consuming alcohol and caffeine for 48 hours and to refrain from eating for two hours prior to the investigation. Furthermore, they were required not to physically exhaust themselves for 24 hours prior to the investigation. For their participation, subjects received 20 Swiss Francs and a meal once the soccer game had ended. All subjects signed informed consent forms. The study was conducted in agreement with the Declaration of Helsinki.

Procedure

Participants arrived two hours before kick-off at our laboratory. Immediate fitting of the ambulatory heart monitors allowed for a habituation period prior to the beginning of the study. We set the start of the observation time 30 minutes before kick-off (t_{-30}). The soccer game commenced at 6:00 p.m. (t_0) and ended goalless at 7:45 p.m. (t_{105}). Measurement intervals for cardiac activity were set before the game ($t_{-30, -2}$), during the first half of the game ($t_{10, 22, 34}$), during the half-time break (t_{52}), during the second half of the game ($t_{70, 82, 94, 103}$), and after the end of the game ($t_{107, 120, 135}$). Time points for cortisol and sAA determination were set as follows: before onset of the game ($t_{-30, -10}$), during the first half (t_{22}),

during the half-time break (t_{46}), during the second half (t_{82}), and after the end of the game ($t_{106, 135}$). Samples to determine testosterone were taken before onset of the game ($t_{-30, -10}$), during the half-time break (t_{46}), and after the end of the game ($t_{106, 120, 135}$). Self-ratings of mood were measured before onset of the game ($t_{-30, -10}$), during the first half ($t_{11, 22, 34}$), during the half-time break (t_{46}), during the second half ($t_{71, 82, 94}$), and after the end of the game ($t_{106, 135}$). Figure 1 summarizes the scheduling of the study.

Cardiac Activity

Cardiac activity was measured using polar s810i devices (Polar, Finland). Inter-beat interval data were examined and edited manually to correct for ectopic beats and arrhythmias using MxEdit²⁵. HR and HRV were analyzed for one-minute intervals. For HRV, high frequency (HF; 0.15-0.40 Hz) and low frequency (LF; 0.04-0.15 Hz) power was analyzed in accordance with the usual recommendations¹⁹.

Biochemical Analysis

We used Salivettes (Sarstedt, Sevelen, Switzerland) for the determination of cortisol and sAA, and Salicaps (Immuno-Biological Laboratories, Hamburg, Germany) for the determination of testosterone. Salivettes were gently chewed for one minute. After collection, saliva samples were stored at -20 °C until assayed for concentration of cortisol, sAA, and testosterone according to standardized procedures^{16,26}.

Self-Ratings

To measure mood alterations during the examination, subjects were asked to rate how stressed they felt and how much they perceived bodily arousal. Answers were provided on visual analogue scales (VAS) ranging from 0 (*not at all*) to 100 (*very much*).

Statistical Analysis

We used SPSS 18 for Windows (SPSS Inc., Chicago, IL). Aggregated values were defined for pre-, peri-, and post-game episodes. Episode aggregation was not undertaken for

cortisol and testosterone since their reactions to stressors are known to be time-lagged. To analyze stress effects, ANOVAs for repeated measures were conducted using the corrected test statistic by Greenhouse-Geisser. The p-level was set at 0.05. Post hoc examination was conducted using the adjusted test statistic by Bonferroni.

Results

Cardiac Activity

HR altered significantly over time, $F(1.79,10.74) = 4.47, p = .042$. No significant effects were observed on HF, $F(1.21,7.24) = 2.475, p = .16$, LF, $F(1.18,7.12) = 1.18, p = .33$, and the LF/HF ratio, $F(1.46,8.73) = .471, p = .58$.

Biochemical Analysis

Concentrations of sAA altered over time, $F(1.31, 7.88) = 9.38, p = .012$. This was due to higher peri-game values than post-game values, $t = 3.42, p = .043$, and there was a trend for the former to be higher than pre-game concentrations, $t = 2.84, p = .09$ (see Figure 2). No significant effect of time was shown for salivary concentrations of cortisol, $F(2.63,15.78) = 1.71, p = .21$, and testosterone, $F(2.69,9.79) = 2.69, p = .12$.

Self-Reports

There was a trend effect for time on perceived stress, $F(1.28,7.70) = 4.49, p = .06$. Post hoc analysis showed that this was due to the trend for increased values during the game compared to post-game values, $t = 2.75, p = .099$. Furthermore, time affected the perception of bodily arousal, $F(1.92,11.52) = 6.08, p = .02$, with values during the game being elevated compared to post-game values, $t = 3.45, p = .04$.

Discussion

HR and sAA activity were significantly increased in response to the game, while HF, LF, the LF/HF ratio, cortisol, and testosterone were unaffected. The game affected perceived bodily arousal, and there was a trend for perceived stress. Peak elevations in both variables

during the two halves of the game indicate that subjects were emotionally captured by the game's action.

HR steadily increased during the game and reached a peak two minutes before the final whistle. These results replicate findings, which reported continually increasing HR during pulsating games¹².

The time course for both HF and LF revealed a pattern of alterations in the expected direction, but the observed changes did not reach statistical significance. While HF power constitutes an index of parasympathetic activity, LF power is influenced by both branches of the ANS. Therefore, together with the finding regarding the HR, it seems that watching the match did not affect parasympathetic activity, but rather sympathetic activity.

This is also supported by the significant increase of sAA during the match. The courses of sAA levels paralleled courses of self-reports on stress and bodily arousal, supporting the notion of sAA, an index of SNS activity, being a sensitive indicator of psychological stress²⁰.

The game halves did not impact on cortisol levels. The finding that the course of cortisol did not change significantly over time supports earlier reports^{22,23}. Significant increases in cortisol found among soccer coaches²⁴ might possibly be explained by coaches' higher ego involvement.

The course of testosterone was not affected by the game. The goalless draw did not enable the testing of potential changes in testosterone after goal-scoring or winning or losing the game, respectively, as have been reported elsewhere²⁷.

To our knowledge, this is the first study to explore the responsiveness of HRV and sAA to stress deployed by attending a soccer game. Our observation of similarities between the courses of sAA, HF and LF and the self-reported mood variables is of interest regarding the search for fast-reacting biological parameters, which can be used to measure and assess

the subjective experience of stress on the biological level without long latency periods. The inclusion of multiple measurements with relatively short intervals has proved promising and should be considered in future studies. A limitation of the study is its low sample size, which should be rectified in future investigations. Furthermore, this study did not include a control condition in order to examine whether the lack of significance of physiological responses was due to delayed endocrine responses, or to counterbalancing circadian rhythms or attentional changes.

The finding of altered sAA activity, besides HR alterations, underlines the primary involvement of the sympathetic nervous system in sports event attendance as being a risk factor for the occurrence of adverse cardiovascular events. At the same time, HRV data from our pilot study seem to suggest a lesser importance of the parasympathetic nervous system in these events. Similarly, watching soccer did not affect concentrations of cortisol and testosterone. Further research is required to reinforce the findings of this pilot study.

References

- 1 Katz E, Metzger JT, Marazzi A, Kappenberger L. Increase of sudden cardiac deaths in Switzerland during the 2002 FIFA World Cup. *Int J Cardiol.* 2006 ;107: 132-3.
DOI:10.1016/j.ijcard.2005.01.029
- 2 Katz E, Metzger JT, Schlaepfer J, Fromer M, Fishman D, Mayer L, et al. Increase of out-of-hospital cardiac arrests in the male population of the French speaking provinces of Switzerland during the 1998 FIFA World Cup. *Heart.* 2005; 91: 1096-7.
DOI:10.1136/hrt.2004.045195
- 3 Carroll D, Ebrahim S, Tilling K, Macleod J, Smith GD. Admissions for myocardial infarction and World Cup football: database survey. *BMJ.* 2002; 325: 1439-42.
- 4 Witte DR, Bots ML, Hoes AW, Grobbee DE. Cardiovascular mortality in Dutch men during 1996 European football championship: longitudinal study. *BMJ.* 2000; 321: 1552-4.
- 5 Brunekreef B, Hoek G. No association between major football games and cardiovascular mortality. *Epidemiology.* 2002; 13: 491-2.
- 6 Berthier F, Boulay F. Lower myocardial infarction mortality in French men the day France won the 1998 World Cup of football. *Heart.* 2003; 89: 555-6.
DOI:10.1136/heart.89.5.555
- 7 Leeka J, Schwartz BJ, Kloner RA. Sporting events affect spectators' cardiovascular mortality: It is not just a game. *Am J Med.* 2010; 123: 972-7.
DOI:10.1016/j.amjmed.2010.03.026
- 8 Baumhäkel M, Kindermann M, Kindermann I, Böhm M. Soccer world championship: a challenge for the cardiologist. *Eur Heart J.* 2007; 28: 150-3.
DOI:10.1093/eurheartj/ehl313

- 9 Bonetti PO, Hunziker PR. Watching football on TV may potentially be life-threatening. *Swiss Med Wkly*. 2006; 136: 228. Available from: <http://www.smw.ch/docs/pdf200x/2006/13/smw-11429.pdf>
- 10 Hijzen TH, Slangen JL. The electrocardiogram during emotional and physical stress. *Int J Psychophysiol*. 1985; 2: 273-9.
- 11 Hüllemann KD, Mayer H, Stahlheber R. [Television and cardiovascular regulation. Circulation studies on myocardial infarct patients and subjects with normal findings during the television transmission of soccer world championship games]. *Munch Med Wochenschr*. 1970; 43: 1401-6. German.
- 12 Rose KD, Dunn FL. The heart of the spectator sportsman. *Med Times*. 1964; 92: 945-51.
- 13 Dishman RK, Nakamura Y, Garcia ME, Thompson RW, Dunn AL, Blair SN. Heart rate variability, trait anxiety, and perceived stress among physically fit men and women. *Int J Psychophysiol*. 2000; 37: 121-33.
- 14 La Marca R, Waldvogel P, Thörn H, Tripod M, Wirtz PH, Pruessner J, Ehlert U. Association between Cold Face Test-induced vagal inhibition and cortisol response to acute stress. *Psychophysiology*. 2010; 48: 420-29. Epub 2010 Jul 26. DOI: 10.1111/j.1469-8986.2010.01078.x
- 15 Nater UM, Rohleder N, Gaab J, Berger S, Jud A, Kirschbaum C, Ehlert U. Human salivary alpha-amylase reactivity in a psychological stress paradigm. *Int J Psychophysiol*. 2005; 55: 333-42. DOI:10.1016/j.ijpsycho.2004.09.009
- 16 Nater UM, La Marca R, Florin L, Moses A, Langhans W, Koller MM, Ehlert U. Stress-induced changes in human salivary alpha-amylase activity – associations with adrenergic activity. *Psychoneuroendocrinology*. 2006; 31: 49-58. DOI:10.1016/j.psyneuen.2005.05.010

- 17 Sloan RP. Effects of mental stress throughout the day on cardiac autonomic control. *Biol Psychol.* 1994; 37: 89-99. DOI:10.1016/0301-0511(94)90024-8
- 18 Akselrod S, Gordon D, Ubel FA, Shannon DC, Barger AC, Conen RJ. Power spectrum analysis of heart rate fluctuation: A quantitative probe of beat-to-beat cardiovascular control. *Science.* 1981; 213: 220-2. DOI:10.1126/science.6166045
- 19 Task Force of the European Society and Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability. Standards of measurements, physiological interpretation, and clinical use. *Eur Heart J.* 1996; 17: 354-81.
- 20 Van Stegeren A, Rohleder N, Everaerd W, Wolf OT. Salivary alpha amylase as marker for adrenergic activity during stress: effect of betablockade. *Psychoneuroendocrinology.* 2006; 31: 137-41. DOI: 10.1016/j.psyneuen.2005.05.012
- 21 Dickerson SS, Kemeny ME. Acute stressors and cortisol responses: a theoretical integration and synthesis of laboratory research. *Psychol Bull.* 2004; 130: 355-91. DOI:10.1037/0033-2909.130.3.355
- 22 Edwards DA, Wetzel K, Wyner DR. Intercollegiate soccer: saliva cortisol and testosterone are elevated during competition, and testosterone is related to status and social connectedness with teammates. *Physiol Behav.* 2006; 87: 135-43. DOI:10.1016/j.physbeh.2005.09.007
- 23 Tegelman R, Carlström K, Pousette Å. Hormone levels in male ice hockey players during a 26-hour cup tournament. *Int J Androl.* 1988; 11: 361-8. DOI:10.1111/j.1365-2605.1988.tb01009.x
- 24 Kugler J, Reintjes F, Tewes V, Schedlowski M. Competition stress in soccer coaches increases salivary immunoglobulin A and salivary cortisol concentrations. *J Sports Med Phys Fitness.* 1996; 36: 117-20.

- 25 Porges SW, inventor; Porges SW, assignee. Method and apparatus for evaluating rhythmic oscillations in aperiodic physiological response systems. United States patent US 4510944. 1985 Apr 25.
- 26 Dressendorfer RA, Kirschbaum C, Rohde W, Stahl F, Strasburger CJ. Synthesis of a cortisol-biotin conjugate and evaluation as a tracer in an immunoassay for salivary cortisol measurement. *J Steroid Biochem Mol Biol.* 1992; 43: 683–92.
- 27 Bernhardt PC, Dabbs JM, Fielden JA, Lutter CD. Testosterone changes during vicarious experiences of winning and losing among fans at sporting events. *Physiol Behav.* 1998; 65: 59-62.

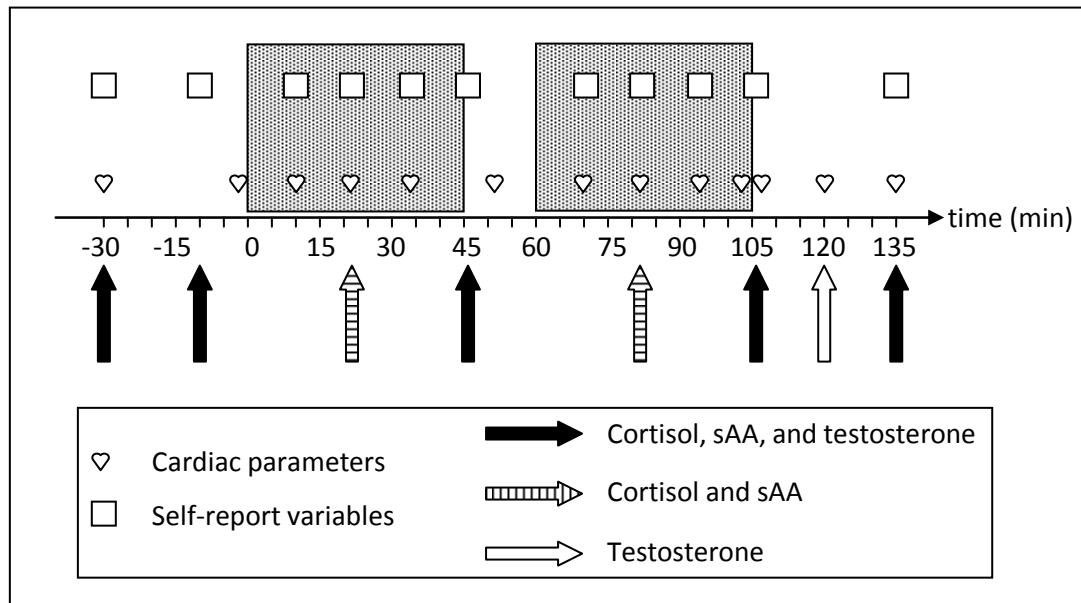
Figure 1. Schematic illustration of the study's course

Figure 1. Shaded rectangles indicate halftimes. Symbols represent collection points for the corresponding variables.

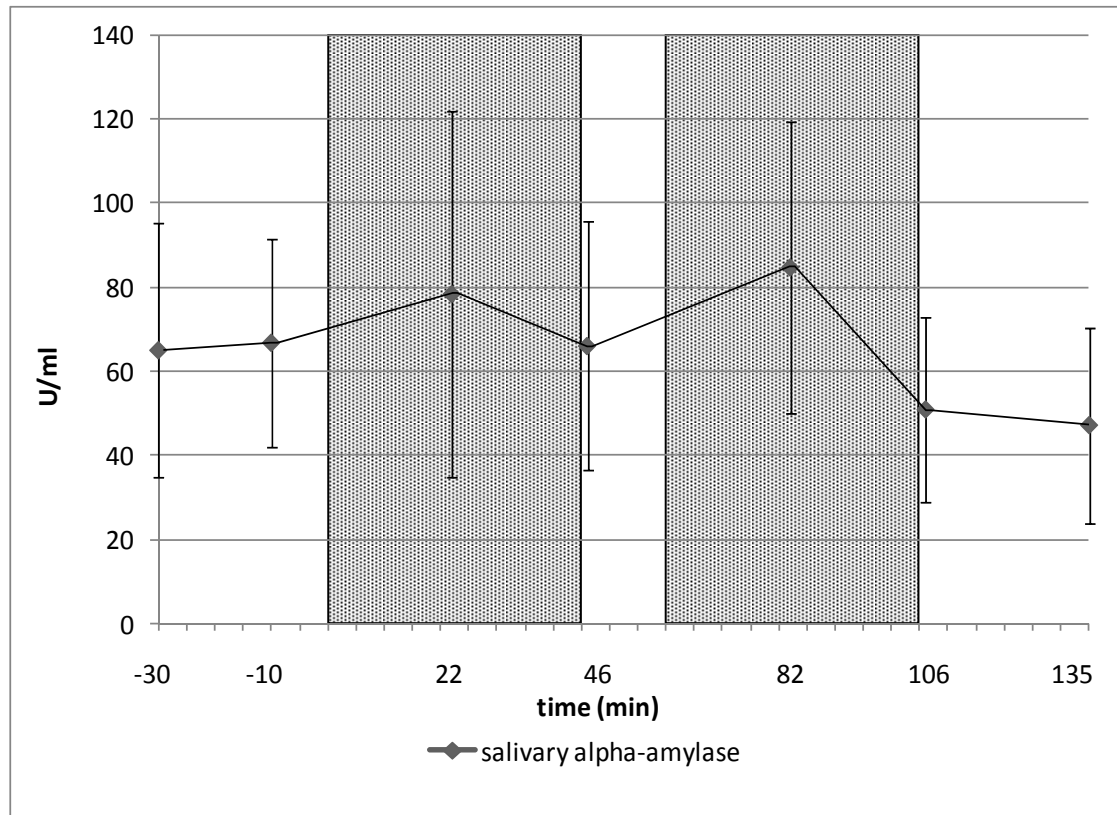
Figure 2. Course of mean alpha-amylase concentration

Figure 2. Course of mean alpha-amylase concentration. Error bars represent standard deviations. Shaded areas indicate the two game halves.