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# Anticipating Injuries and Health Problems in Elite Soccer Players Using Dynamic Complexity

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### 1. Background

- Injuries and health problems of soccer players often appear abruptly and unexpectedly;
- Complex systems theory suggest that these events can be preceded by Early Warning Signals (EWSs) [1];
- Dynamic complexity (DC) is an EWS reflecting changes in variability and turbulence [2,3];
- We tested whether changes in DC, detected in soccer players' psychophysiological measures, anticipate injuries and health problems.

#### 2. Methods

- 14 male players of a Dutch major league (Eredivisie) club were measured on every training and match day over two competitive seasons;
- We collected psychological and physiological self-reports on self-efficacy, motivation, mood, rating of performance, enjoyment, recovery (Figure 1), and we used heart rate sensors;
- Time-loss injuries and health problems (OSTRC-H2) were the outcome measures;
- We calculated the DC of the self-reports and sensor data in a seven-day window to detect increased variability before injuries and health problems occurred.

#### 3. Results

- Players experienced 2.7 injuries and 8.3 health problems on average across two seasons;
- In the five days before injuries and health problems, DC increased in 26% and 33% of the payers, respectively (Figure 2).

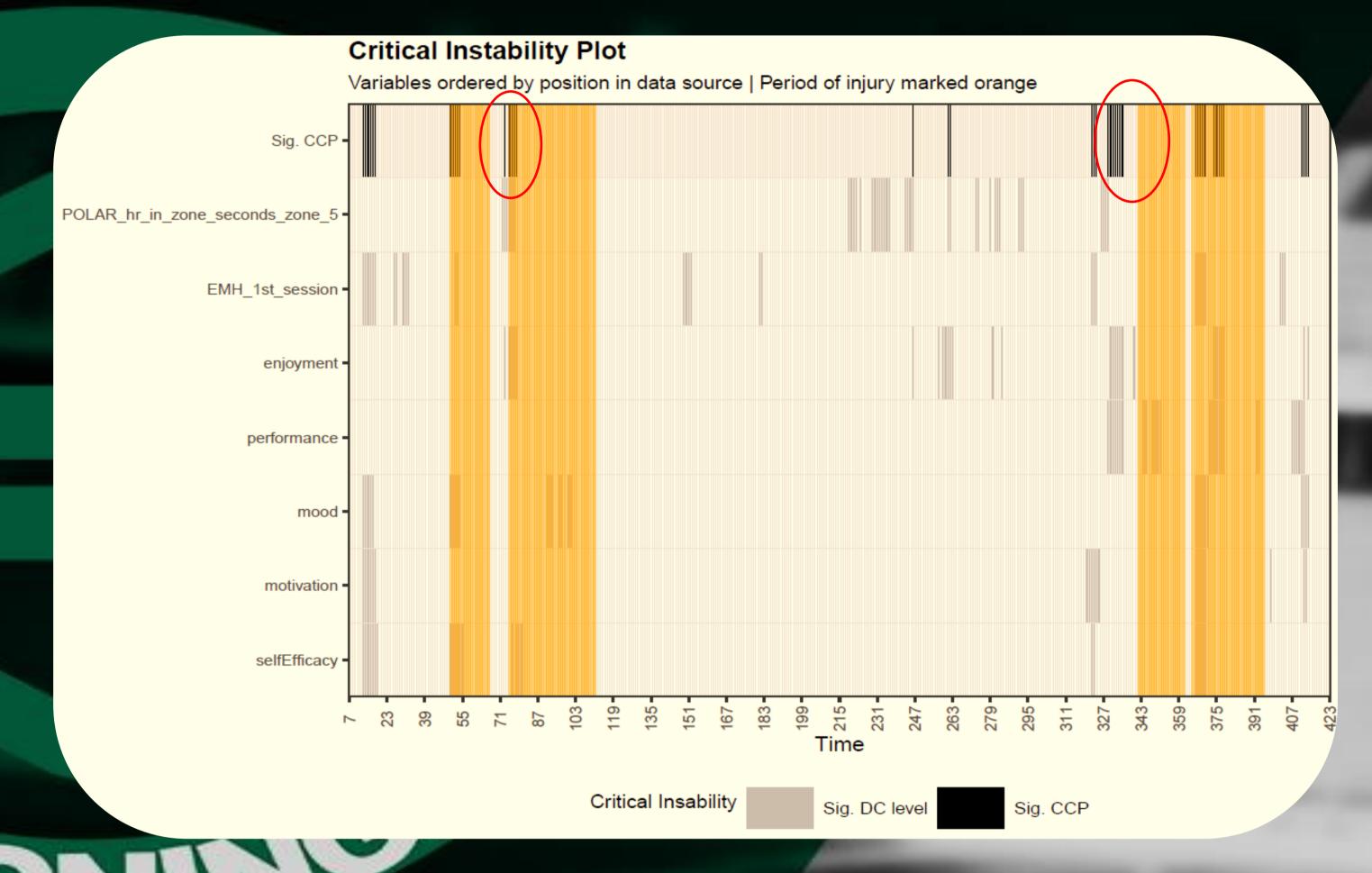


Figure 2. Critical instability plot showing the significant cumulative complexity peaks (CCP; i.e., all measured variables together) as black lines in the top row, and the significant dynamic complexity level for every single variable as grey lines in the remaining rows. The data represents one player over two competitive seasons. The red circles highlight the CCPs before the onset of an injury. Thus, an EWS.

## 4. What does this mean?

- Results of this study suggest that EWSs can be used for real-time anticipation of injuries and health problems in daily soccer practice;
- Future research should test for the robustness of these results within and between individuals and perform sensitivity and specificity tests;
- Finding out how warning signals can be communicated to soccer players and staff is an interesting avenue.



Figure 1. Illustration of the tailor-made app that we made to fill out the self-reports on a tablet computer.

#### References

[1] Den Hartigh RJR, Meerhoff LRA, Van Yperen NW, et al. Resilience in Sports: A Multidisciplinary, Dynamic, and Personalized Perspective. Int Rev Sport Exerc Psychol. 2022.

[2] Ölthof M, Hasselman F, Strunk G, et al. Critical Fluctuations as an Early-Warning Signal for Sudden Gains and Losses in Patients Receiving Psychotherapy for Mood Disorders. Clin Psychol Sci. 2020;8(1):25-35. [3] Schiepek, G., & Strunk, G. (2010). The identification of critical fluctuations and phase transitions in short term and coarse-grained

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