

Percolation processes in network physiology of exercise. Understanding injuries and fatigue-induced task disengagement

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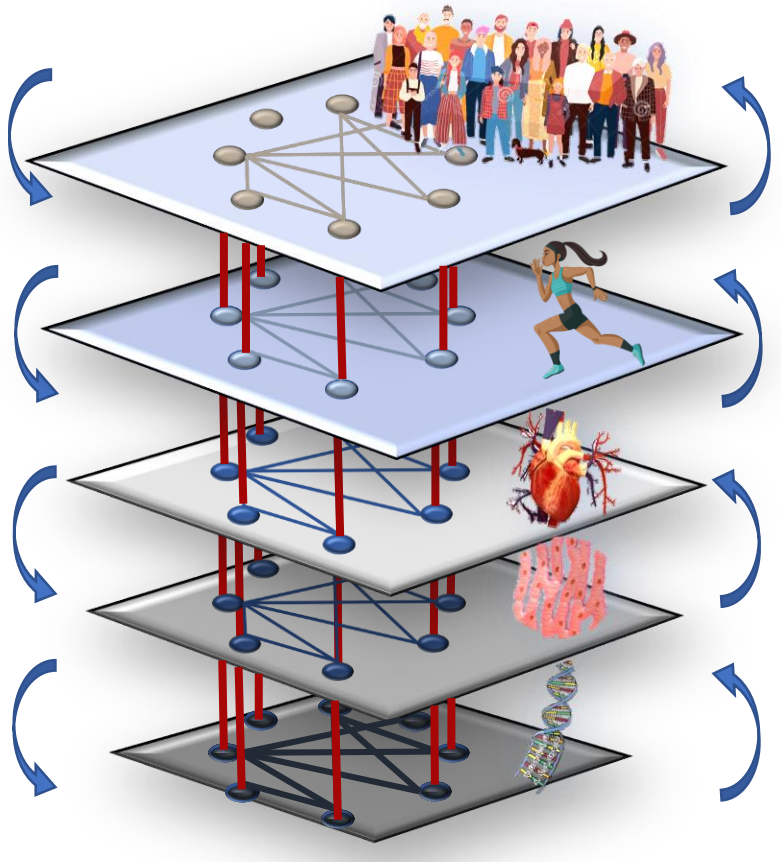
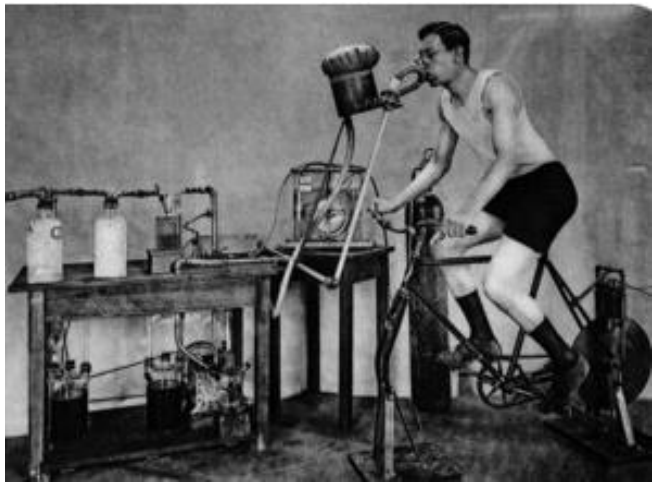
EXERCISE PHYSIOLOGY

NETWORK PHYSIOLOGY OF EXERCISE

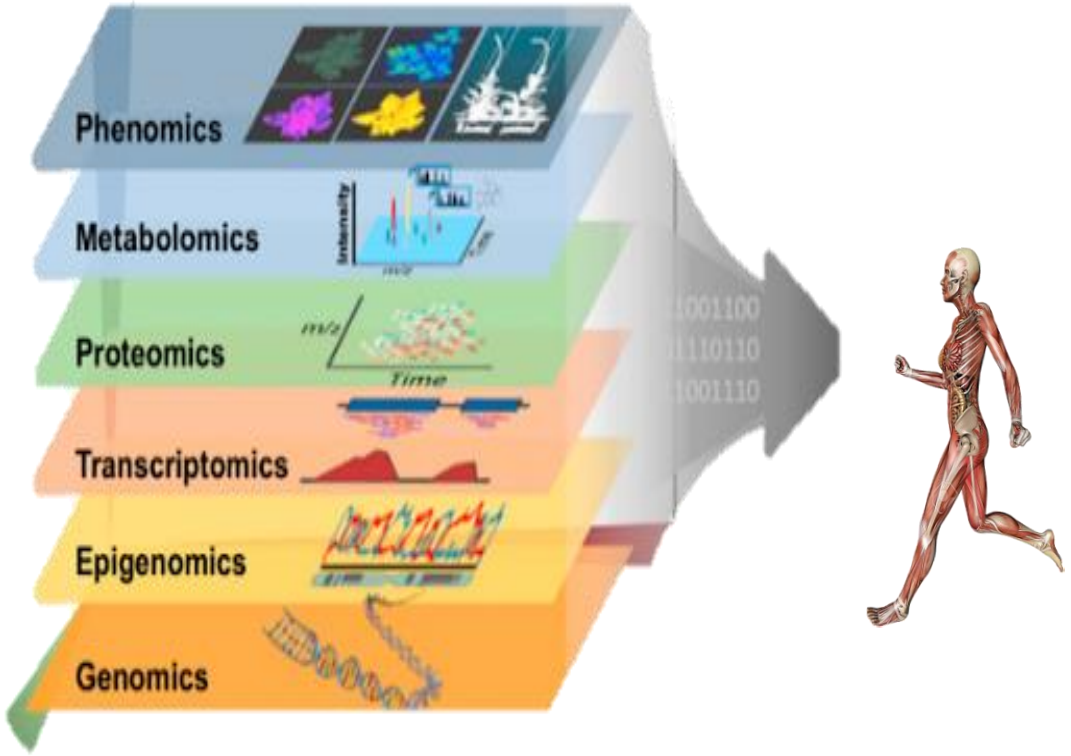


Advances in technology?



(Hopkins, 2013; Montull et al., 2022)

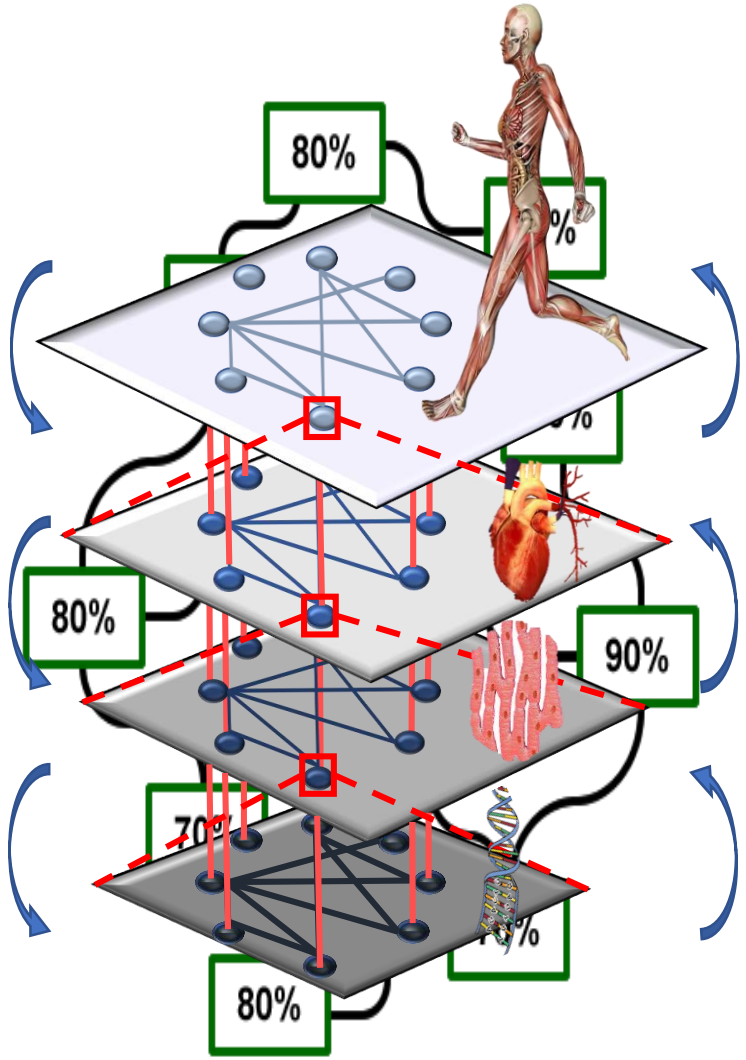
Molecular exercise physiology?



Sportomics approach

- Non dynamic
- Group pooled data
- Bottom-up statistical inferences

Is the molecular level adequate to capture relevant physiological events?



Network running normally

Relevant physiological events:

sports injuries
fatigue-induced task disengagement

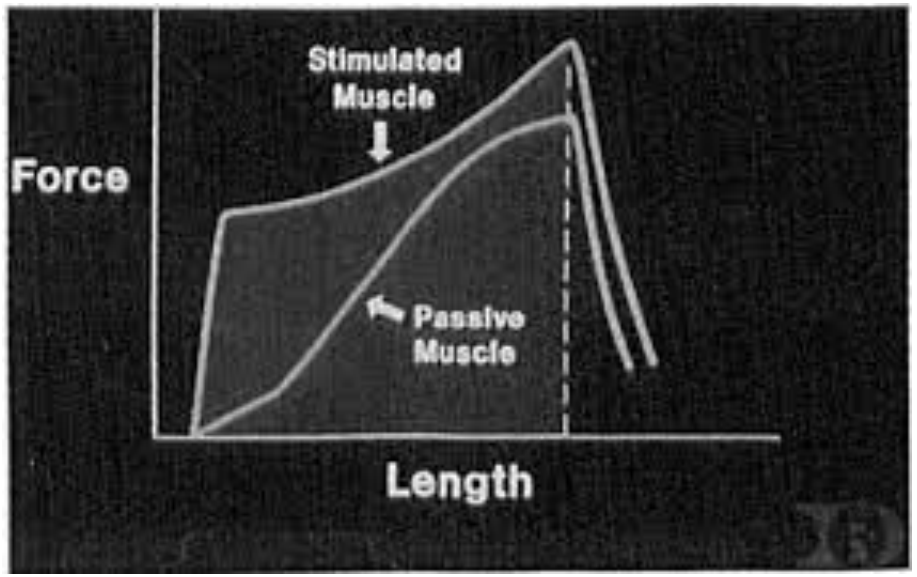
- **Sports injuries**: loss of body function or structural integrity occurring instantly through sports activities

- **Fatigue-induced spontaneous task disengagement:** Abrupt coordinative shift to a lower energy level that occurs with fatigue

Non-contact sport injuries

Injuries understanding

cause-effect inferences from micro to macro level

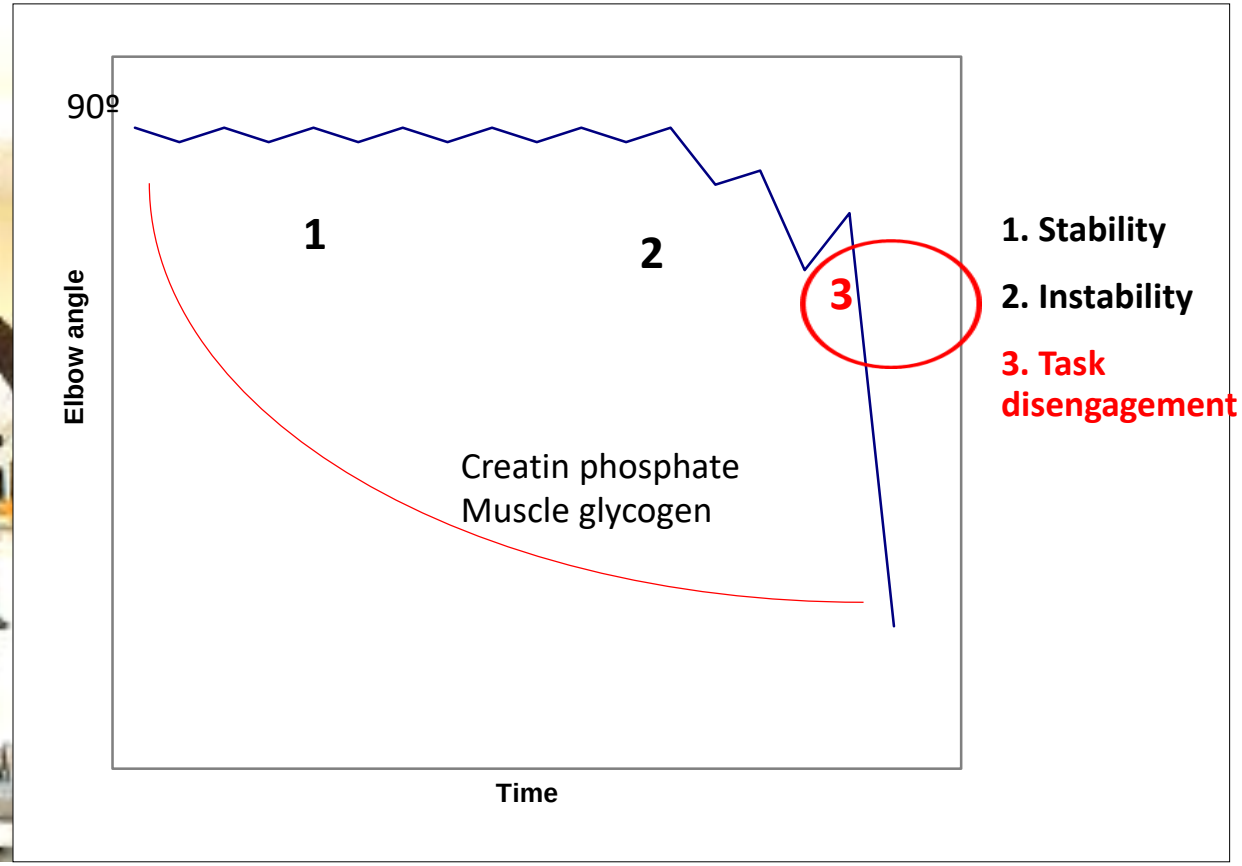


(Garrett, 1996)

Eccentric exercise programs

Fatigue-induced task disengagement

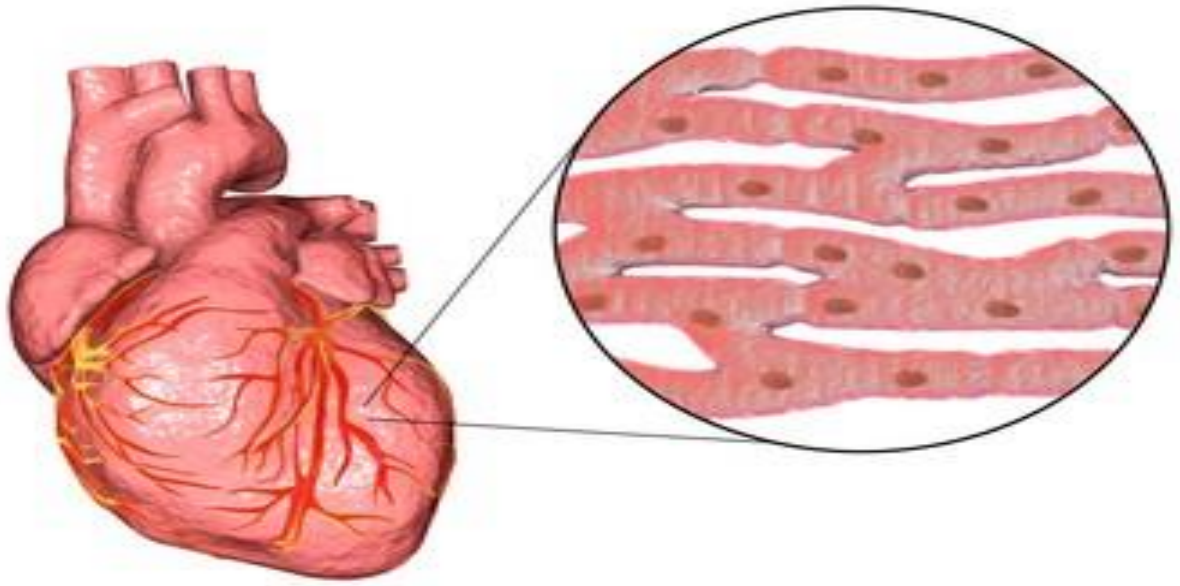
Cause: metabolic substrates?



(Hristovski and Balagué. 2010; Vázquez et al., 2016)

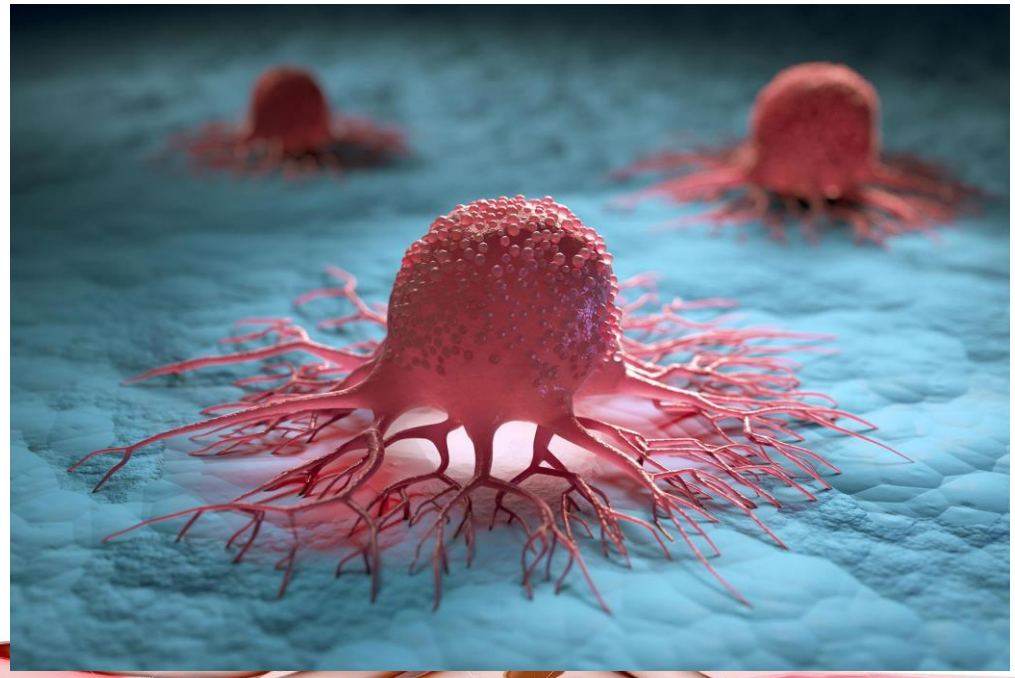
Enhanced instability
Why focusing on the microlevel?

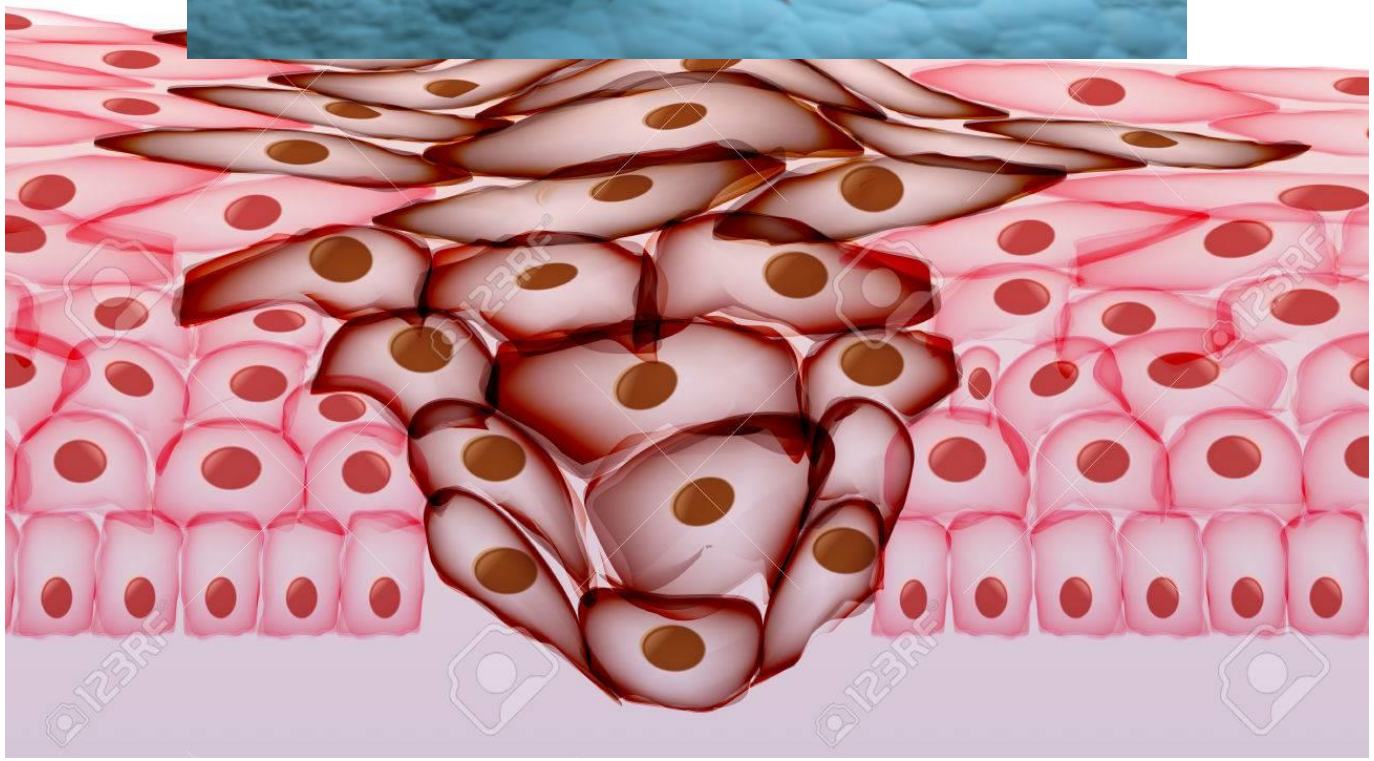
Mesoscopic approach



CARDIAC RYTHM

SYNCHRONIZED
CELL ACTIVITY
Bradicardia, arritmia,…





Cancer evolution predictions:
Investigating the behaviour of tumoral cells or tumoral tissue?

Fatigue, injuries
Changes of state occurring at behavioural macrolevel

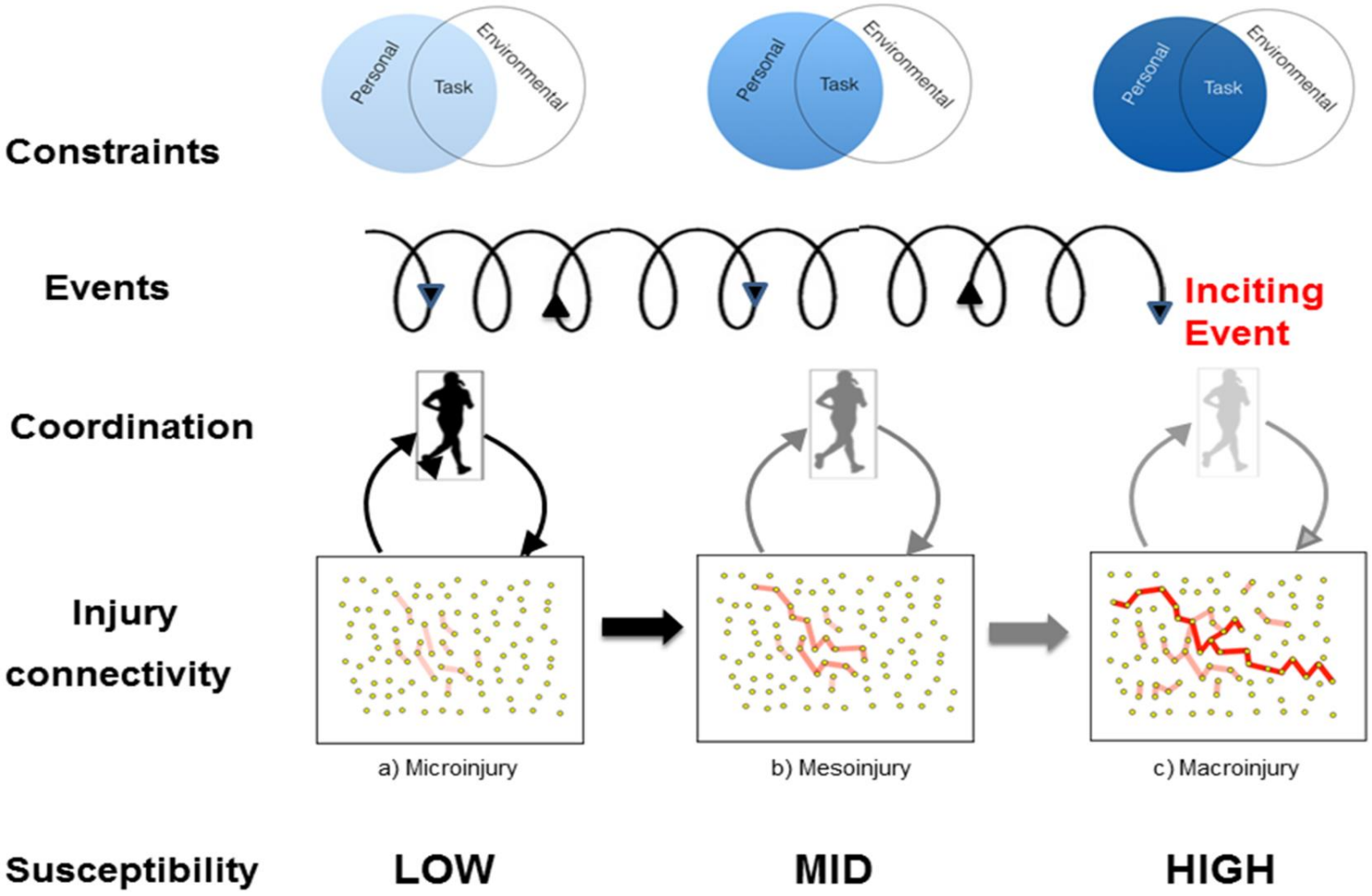
TASK ENGAGEMENT

fatigue

TASK DISENGAGEMENT

injury

From micro to macro injuries
Connectivity/percolation hypothesis

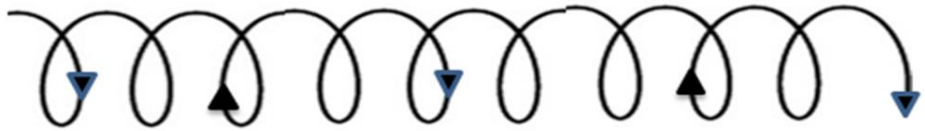


Pol, Hristovski, Medina, Balagué, BJSM , 2018

Fatigue-induced spontaneous task disengagement. Percolation or cascading failure effects

Constraints

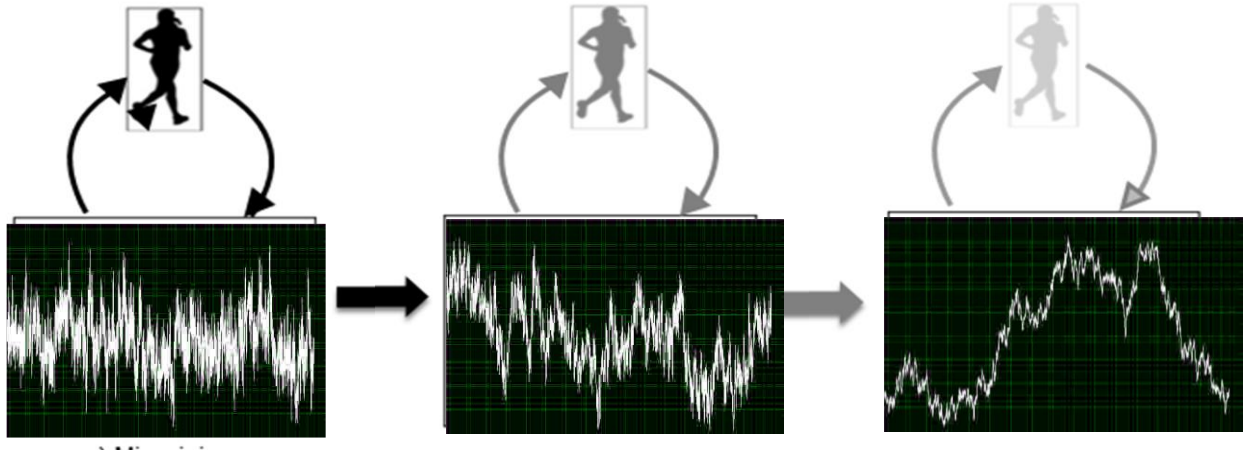
Events



Task disengagement

Coordination

Variability



a) Antipersistent fBm

b) Antipersistent fBm (lower H exponent)

c) Persistent fBm

Control

FLEXIBLE

MID

RIGID

(Vázquez, Hristovski, Balagué., Front Physiol. 2016)

Injuries and fatigue. Common dynamics

TASK ENGAGEMENT

Path to injuries

Synergetic reconfigurations, coordinative changes
Reduction of degrees of freedom
Loss of efficiency
Pain
Microinjuries

TASK DISENGAGEMENT

Path to exhaustion

"adaptive protective mechanisms that enforce time for recovery"

Pol, Hristovski, Medina, Balagué, BJSM , 2018

Theoretical assumptions	Exercise Physiology	Network Physiology of Exercise
Systems	Dominated by their components	Dominated by network interactions among system components
Theory	Cybernetic Control Theory	Adaptive Networks, Dynamic Systems Theory, Nonlinear Dynamics, Statistical Physics
Control	Programs (CNS and DNA)	Parametrically regulated system
Mechanisms goal	Homeostatic	Homeodynamic, synchronization, criticality

(Balagué, García-Retortillo, Hristovski, Ivanov, in press)

Methodology	Exercise Physiology	Network Physiology of Exercise
Variables	Molecular mechanisms and networks	Networked meso- or macroscopic collective variables
Data acquisition	Group-pooled data	Intra-individual multiple time series
Measures	Means and max values of variables	Connectivity/Transfer entropy/Mutual information/Phase coherence/Coupling functions/Phase synchronization/Time-delay stability
Analysis	Population to individual generalization	Individual to population generalization
Relations	Bottom-up	Bottom-up and top-down

(Balagué, García-Retortillo, Hristovski, Ivanov, in press)

Conclusion

A better understanding of sport and exercise-related phenomena may be achieved through the search of the network dynamics of individual meso- and macroscopic variables

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