The Geography of Fatigue:

Making Performance Difficulties Interpretable for college Women Athletes through Layered XAI Design

Visualizing the interaction between training load and physiological variability over time

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RESEARCH QUESTION

How can the design of a layered, temporal user interface for an AI-supported training system help college women athletes interpret their individual performance reviews by visualizing how training load and physiological variability data interact to influence fluctuations in individual performance over time?

PROBLEM SCOPE

Data Bias in Women Athletes

- Although there are 242,341 female student-athletes in the NCAA (2023–24 record high), only 35% of sports performance research includes women, resulting in training standards largely based on male physiology (Meignié et al., 2021).

Missing Physiological Context

- This gap creates a critical blind spot in training systems.
- Menstrual cycle variability is often treated as a “confounder,” leading to the exclusion of women from research (Meignié et al., 2021; Arenas-Pareja et al., 2023).
- Yet it directly impacts performance and safety. For example, injury risk increases by up to 47% in certain phases (MacMillan et al., 2024).
- Current systems fail to reflect the physiological rhythms and lived experiences of women athletes.

Limited System Support

- A $3.99B industry is rapidly shifting toward AI-powered, individualized training.
- With models reaching 93% accuracy, AI presents a critical opportunity to close the data gap for women athletes (Dijkhuis et al., 2018).

Resulting Athlete Confusion

- “Gender-neutral” AI systems remain opaque, offering little physiological context.
- Athletes struggle to connect fatigue with cycle variability, leading to anxiety and loss of bodily agency.

TALKING TO ATHLETES

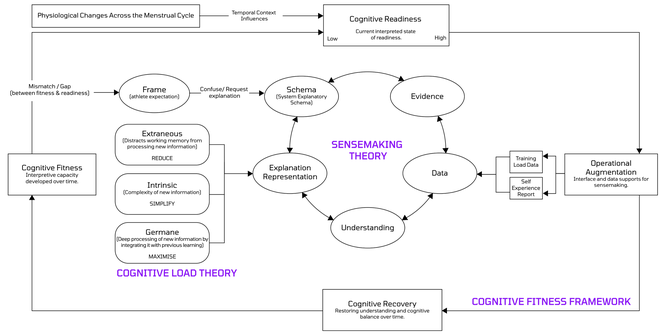
What They Shared

- Athletes navigate tension between data and bodily experience.
- While wearable metrics are widely collected, they are rarely explained, leaving athletes confused when data mismatch with their lived experience.
- Menstrual cycle fluctuations further shape training capacity, yet athletes often feel pressure to suppress or ignore these changes within competitive environments.
- As a result, generic AI or coaching advice fails to account for individual variation, leading to confusion and loss of trust.
- Athletes prefer explanations over automated decisions to maintain control.

CONCEPTUAL FRAMEWORK

This project combines Sensemaking Theory (Weick, 1995), Cognitive Load Theory (Sweller, 1988), and the Cognitive Fitness Framework (Aidman, 2020) to frame how athletes interpret performance fluctuations through the relationship between training load, physiological variability, and lived experience.

Guided by these frameworks, the design structures and layers information to make these relationships interpretable over time, supporting athletes’ sensemaking and cognitive readiness.



MAPPING THE USER JOURNEY

PERSONA

Role

College women’s basketball player, 2nd-string small forward

Team

Joined university team 6 months ago

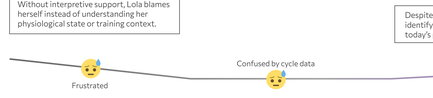
Training Frequency

6 times/week (coach-led and personal effort)

Personality

Introvert — Extrovert
Busy — Time Rich
Messy — Organized
Independent — Team Player
Passive — Active
Safe — Risky

TIMELINE	LATER AFTER THE TRAINING	TURNING TO CYCLE-BASED EXPLANATION	REVIEWING TRAINING HISTORY	SEEKING EXTERNAL GUIDANCE	STILL UNRESOLVED
Actions	Review the day’s training and make sense of a disappointing performance.	Checks whether her physiological cycle explains her condition.	Looks for changes or abnormalities in recent training.	Asks an AI system for guidance.	Ends the day without a clear explanation.
Sub Task	After returning from training, Lola feels dissatisfied with her performance. She syncs her data and reviews duration, heart rate, and calorie burn. She keeps replaying moments from training and scrimmage in her mind. She compares today’s performance with her usual level. She wants to understand why she is struggling.	Suspects her symptoms may be related to her cycle. Opens a cycle tracking app to check timing (period in 3 days). Links fatigue and emotional changes to her upcoming period. Looks for a physiological explanation for her performance difficulty.	Reviews heart rate, duration, and calories. Switches to weekly and bi-weekly views for a broader perspective. Scans training types and accumulated volume. Despite a consistently high training load, she cannot identify clear differences.	Describes dissatisfaction with recent performance. AI reassures her and offers general advice. AI told her the performance is really common for every athlete, especially for the people who had heavy training load. Clarifies that her training volume is already high(6 sessions/week, 2.5 hours each). Has limited control over her training load or schedule.	Accepts that “performance fluctuates.” Stops thinking about it for the night. Hopes her emotions won’t affect her sleep or next day’s training. Carries lingering confusion into the next training day.
Pain Points	Performance difficulties lack clear explanations. Without interpretive support, Lola blames herself instead of understanding her physiological state or training context.	Cycle apps show timing, but not how it affects performance.	Data appears as numbers, not meaning ful relationships, too much data, no interretation. Despite extensive metrics, Lola cannot identify what changed or what explains today’s performance drop.	AI assumes she can adjust training, overlooking real constraints from coaching and schedules. AI ignores real constraints and offers generic advice. The explanation doesn’t connect effort, constraints, and outcomes. It feels supportive , but not actionable.	Emotional discomfort fades, but she still lacks understanding of her performance in relation to her body and training context. Emotional discomfort fades, but uncertainty remains, affecting her rest and the next day’s training.
Opportunity	Make physiological state understandable beyond isolated metrics. Reframe performance struggles as state, not ability.	Integrate cycle, training, and biometric data to support embodied understanding, not memory, based inference.	Align physiological rhythms with training demands in a shared visual frame. Connect data to readiness to make performance states intuitive.	Ground explanations in real training constraints, clarifying why struggles occur despite high effort.	Design systems that support understanding without prescribing action, restoring agency through insight.
Tech Use	Smartwatch & Training App	Menstrual cycle tracking app	Training app (historical summaries)	AI tools	



CONCEPT DEVELOPMENT

This system of interfaces is designed to address the gap identified in current training systems, where physiological variability and lived bodily experience are often overlooked.

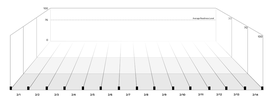
It supports athletes’ sensemaking by connecting external training load with internal bodily experience over time. Through integrated visualization and layered explanations, it helps athletes understand performance fluctuations, uncover underlying causes, and navigate future readiness.

External Training Load

External Training Load

Objectively measurable demands (duration, distance, volume) applied to an athlete during training or competition (Soligard et al., 2016).

Design Strategy - Spatial Training Load Map



Athlete Internal Experience

Internal Load

Athletes’ subjective responses to training, including perceived effort, stress, and physiological strain (Soligard et al., 2016).

Signal Expression

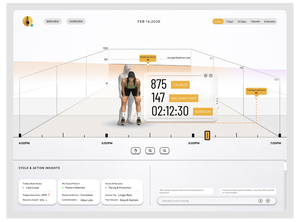
Athletes’ body language acts as a key indicator of internal states, such as confidence and perceived pressure (Furley & Roth, 2021).

Design Strategy - Body Language as Internal Signal

Daily Insights

Linking Experience to Performance

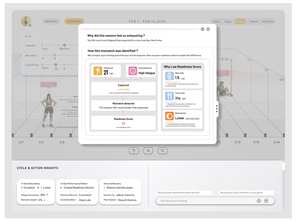
A context-aware interface that connects subjective bodily experience with training load and personal baseline, enabling athletes to compare perceived effort with typical performance and understand shifts in their current state.



Layered Explanation

Unpacking AI Reasoning

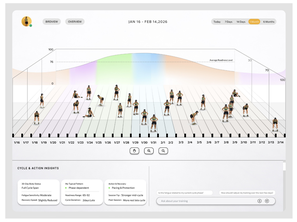
A layered explanation interface that progressively unpacks AI reasoning, enabling athletes to understand how physiological and training factors contribute to their performance experience.



Trend Navigation

Spatial Performance Mapping

A temporal visualization interface that maps performance over time, enabling athletes to identify recurring patterns and build long-term contextual awareness of their performance state.



FUTURE WORK

Cross-Device Adaptation

Expanding the interface for multi-screen use, ensuring seamless data accessibility across mobile and larger display environments.

Coach-Athlete Communication

Exploring features that allow athletes to share subjective status reports with coaches to facilitate collaborative training adjustments.

Longitudinal Data Visualization

Developing methods to visualize long-term trends by integrating objective performance metrics with subjective wellness data over time.

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