Architecting the Adaptive Athlete: A Comprehensive Taxonomy of User Input Parameters in Computational Training Systems

1. Introduction: The Cybernetic Loop of Athletic Performance

The paradigm of athletic training is undergoing a fundamental transformation, shifting from static, linear periodization models—often delivered via immutable spreadsheets or PDFs—to dynamic, computational ecosystems known as Adaptive Training Algorithms (ATAs). These systems promise a "coach-in-the-pocket" experience, utilizing machine learning and heuristic logic to tailor training loads to the individual's evolving physiology. However, the efficacy of an ATA is not defined solely by the sophistication of its internal biological model or the granularity of the objective data (power, heart rate, pace) it ingests. Rather, the system's intelligence is strictly bounded by its ability to perceive the athlete's context.

In cybernetic theory, a control system requires a feedback loop to correct errors and maintain stability. In the context of human performance, objective data provides the *result* of the system (e.g., the athlete generated 300 watts), but it often fails to capture the *state* of the system (e.g., the athlete generated 300 watts while experiencing high anxiety, low glycogen availability, and significant sleep deprivation). Without explicit User Input Parameters (UIPs), the algorithm operates in a "black box," making assumptions about causality that can lead to non-functional overreaching or undertraining.[1]

This report presents an exhaustive analysis of the essential user input parameters required to construct a robust, human-centric adaptive training system. It synthesizes research from physiological monitoring, psychometrics, and user interface design to establish a taxonomy of inputs across the athlete's journey: from the initial initialization of goals (The Genesis Vectors) to the daily assessment of capacity (The Readiness Loop), the post-hoc analysis of execution (The Feedback Mechanism), and finally, the user interface logic required to close the loop (Dynamic Adjustment).

The analysis reveals that the most effective algorithms do not merely automate prescription; they facilitate a dialogue. They weigh objective metrics against subjective reality, utilizing user inputs not just as data points, but as "weighting coefficients" that modulate the algorithmic response to physiological load.[3] As we explore these parameters, it becomes evident that the future of training software lies in minimizing the friction of these inputs while maximizing their impact on the training plan's evolution.

2. The Genesis Vectors: Goal Setting and Initialization Parameters

The initialization phase of an adaptive algorithm—commonly presented to the user as a "Goal Setting Wizard" or "Onboarding Flow"—is the most critical juncture for algorithmic accuracy. This phase establishes the "North Star" metrics against which all future adaptations are measured. If the input parameters here are vague or poorly structured, the algorithm's trajectory will be fundamentally flawed. Research into goal-setting theory within sports psychology emphasizes the necessity of the SMART framework (Specific, Measurable, Achievable, Relevant, Time-bound).[4] A sophisticated ATA must translate these qualitative concepts into quantitative input fields.

2.1 Event Profiling and Prioritization Logic

The primary vector for any training plan is the target event. However, a single date is insufficient for complex periodization. The system requires a high-resolution "Event Profile" to reverse-engineer the specific physiological demands—energy systems, biomechanical loads, and environmental stressors—that the athlete must be prepared to endure.

2.1.1 Event Hierarchies and Tapering Logic

Adaptive systems must force users to prioritize their competitive calendar. It is physiologically impossible to peak for every event in a season. Therefore, the goal wizard must implement a tiered priority system, commonly categorized as A, B, and C races.[7]

- **"A" Race (The Peak):** The algorithm interprets this input as the singular focus of the macrocycle. It triggers the calculation of a full taper module, typically reducing volume by 40-60% in the preceding 1-3 weeks while maintaining intensity to shed fatigue and maximize freshness (TSB - Training Stress Balance).[7]
- **"B" Race (The Test):** The system interprets this as a high-priority training day. The algorithm may schedule a "mini-taper" (2-3 days of reduced load) but will not disrupt the progressive overload of the mesocycle.
- **"C" Race (The Workout):** The system treats this event purely as a substitute for a high-intensity session (e.g., a Threshold workout). No tapering is applied.

Algorithmic Constraint: The UI must enforce logic that prevents users from selecting conflicting priorities, such as two "A" races within a 14-day window, which would violate the physiological constraints of supercompensation and recovery.[8]

2.1.2 Terrain and Environmental Specificity

The specific topography and surface of an event significantly alter the muscular and metabolic demands. A marathon on flat pavement requires different biomechanical adaptations than a 50km trail ultra-marathon with 2,000 meters of vertical gain. Platforms like Best Bike Split and Vert.run demonstrate the necessity of granular terrain inputs.[9]

- **Surface Type:** Users must select between Road, Trail, Track, Gravel, or Mixed. This input informs the algorithm to prescribe specific muscle-recruitment workouts (e.g., high-torque low-cadence work for climbing vs. high-cadence work for track).[11]
- **Aerodynamic and Gravitational Constraints:** For cycling, inputs regarding the course's elevation profile allow the system to calculate the necessary power-to-weight ratio (Watts/kg) versus absolute power (Watts/CdA) required for success.[9]
- **Technical Difficulty:** In trail running, a "Technicality Score" input allows the system to adjust pace expectations. A 10km run on technical single-track might equate to the physiological load of a 15km road run. Without this input, the algorithm might incorrectly interpret a slow trail run as a decline in fitness.[13]

Table 1: Essential Event Profiling Input Parameters

Parameter Category	Input Field Example	Algorithmic Implication	Source
Event Priority	Select: A, B, or C Priority	Determines Taper length and volume reduction coefficients.	7
Race Approach	Select: "Run for Fun" vs. "Time Goal"	Alters risk profile; "Time Goal" allows for higher ramp rates.	8
Course Topography	Total Elevation Gain (m/ft)	Shifts training focus to strength-endurance (climbing) vs. speed.	10
Surface/Terrain	Road, Trail, Technicality (1-5)	Modifies pace-to-power calculations; adjusts efficiency metrics.	11
Environmental	Expected Temp/Altitude	Triggers heat/altitude acclimation blocks if data is available.	9

2.2 User Constraints and Availability Modeling

A major failure mode of static training plans is the "availability mismatch," where the plan prescribes a 2-hour workout on a day the user only has 45 minutes. To avoid constant rescheduling, the initialization phase must capture the user's *temporal reality*.

2.2.1 Granular Time Constraints

Platforms like TrainAsONE and Runna explicitly query the user for their weekly time budget on a per-day basis.[18]

- **Daily Duration Caps:** The user should input specific windows (e.g., "Tuesday: 06:00-07:00 AM"). This serves as a hard constraint for the workout generator. If a physiological adaptation requires 90 minutes of Time-in-Zone, but the user has only 60

minutes, the algorithm must intelligently substitute a higher-intensity, shorter-duration variant (e.g., compressing volume into intensity) rather than prescribing an impossible session.[20]
- **Long Run Anchoring:** The user must actively select the day for their longest session. While traditionally Sunday, modern work schedules vary. This input anchors the weekly microcycle, with the algorithm back-filling intensity and recovery days relative to this anchor point.[19]

2.2.2 Equipment Inventory and Modality

The "Inventory" input allows the algorithm to tailor the *modality* of the stimulus.
- **Indoor vs. Outdoor:** An input specifying "Indoor Trainer Available" (e.g., Zwift, Peloton) allows the algorithm to prescribe highly specific ergometer-mode intervals that are difficult to execute outdoors due to traffic or terrain.[11]
- **Sensor Availability:** The system must know if the user is training with Power, Heart Rate, or only RPE (Rate of Perceived Exertion). This dictates the language of the workout prescription (e.g., "Hold 250 Watts" vs. "Run at 7/10 Effort").[22]

2.3 Physiological Baselining and History

Before the first workout is generated, the system establishes a baseline. While historical data files provide objective history, subjective history helps gauge *resilience*.
- **Training Age and History:** Questions such as "How many years have you been training?" and "What is your average weekly volume over the last 6 months?" help calculate the user's Chronic Training Load (CTL). This prevents the "Too Much, Too Soon" error, where an algorithm might prescribe a load that is mathematically optimal but orthopedically dangerous for a novice.[7]
- **Current Performance Estimates:** Inputting a recent 5k or 10k time (distinct from the goal time) allows the system to triangulate a VO2 max estimate and set initial zones.[25]
- **Risk Appetite:** A unique parameter observed in TrainAsONE is the "Risk Level" setting. Users can explicitly input their tolerance for injury risk in exchange for faster performance gains. A "High Risk" input allows for steeper ramp rates in volume and intensity, while "Low Risk" flattens the progression curve.[27] This psychometric input effectively shifts the algorithm's internal safety limiters.

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3. The Daily Control Loop: Readiness and Pre-Training Inputs

Once the macro-plan is established, the system enters the daily control loop. The fundamental question shifts from "What *should* the athlete do?" to "What *can* the athlete do today?" This is the domain of **Daily Readiness**. Research indicates that readiness is multi-factorial, comprising physiological, psychological, and biomechanical states.[1] An adaptive system must ingest a composite of these signals to modulate the day's training load.

3.1 Objective Readiness Inputs (Wearable Integration)

Modern ATAs ingest high-fidelity biometric data from hardware ecosystems like Oura, Whoop, and Garmin. While these are "passive" inputs, they are foundational to the readiness score.

- **Heart Rate Variability (HRV):** This is the primary biomarker for autonomic nervous system balance. A significantly suppressed HRV (relative to the user's 60-day baseline) suggests sympathetic overdrive (stress) or parasympathetic saturation (deep fatigue).[28]
- **Resting Heart Rate (RHR) & Body Temperature:** Deviations in RHR or skin temperature are strong leading indicators of illness or infection. Oura's readiness algorithm penalizes scores heavily when temperature deviates by >0.5°C, triggering a "Rest Mode" recommendation.[29]
- **Sleep Hygiene:** The system must analyze not just duration, but the "Restorative Time" (Deep + REM sleep). Whoop's recovery score creates a weighted average of Sleep Performance, HRV, and RHR to generate a 0-100% capacity signal.[28]

3.2 Subjective Readiness: The Human Validation Layer

Objective metrics are prone to false positives. A low HRV might be caused by a late meal or mild dehydration rather than systemic training fatigue. Therefore, the "Human-in-the-Loop" is required to validate the biometric signal. This subjective validation is the most critical "active" input in the pre-training sequence.[1]

3.2.1 The Freshness Feedback Mechanism (Xert)

The Xert platform utilizes a sophisticated "Freshness Feedback" slider, allowing users to manually offset the algorithm's calculated state.

- **Mechanism:** The slider ranges from -60 (Very Tired) to +60 (Very Fresh).
- **Application:** If the objective model calculates a "Fresh" state (Blue status), but the user feels lethargic due to non-training stressors (work stress, travel), dragging the slider to "-20" instantly updates the user's "Form" score. This real-time input triggers the Adaptive Training Advisor (XATA) to downgrade the day's recommended workout from a high-intensity "Breakthrough" session to a sub-threshold endurance ride.[33] This is a prime example of user input acting as a *veto* power over the algorithm.

3.2.2 Wellness Questionnaires and Psychometrics

Subjective questionnaires provide context that wearables miss. Leading athlete management systems utilize specific fields to capture these "invisible" loads.[35]

- **Muscle Soreness (DOMS):** Users rate soreness on a 1-10 scale or select specific muscle groups on a body map. High localized soreness with normal HRV indicates peripheral fatigue (muscle damage) rather than central fatigue (CNS). The algorithm should respond by maintaining aerobic volume but reducing neuromuscular intensity (e.g., no sprints).[32]
- **Motivation and Mood:** Questions like "How motivated are you to train?" (Likert 1-5) are

predictive of burnout. A longitudinal drop in motivation, even with stable physical metrics, is a marker of *Non-Functional Overreaching* (NFO).[1]
- **Life Stress:** Inputs rating "Non-training Stress" acknowledge that the body does not distinguish between cortisol produced by intervals and cortisol produced by a stressful workday. High life stress inputs should trigger a reduction in training intensity to preserve the total allostatic load capacity.[37]

3.3 Physiological Constraints: Women's Health and Cycle Tracking

A critical, often overlooked input parameter in legacy systems is the menstrual cycle. Research highlights that hormonal fluctuations significantly alter substrate metabolism, thermoregulation, and recovery capacity.[38] Platforms like Wild.AI and Oura have pioneered the integration of these inputs.

- **Cycle Phase Input:** The user tracks their current cycle day or phase (Follicular, Ovulatory, Luteal).
- **Algorithmic Adaptation:**
    - *Follicular Phase:* Estrogen is dominant; recovery is faster, and strength capacity is higher. The algorithm should weight high-intensity and strength sessions more heavily during this window.[38]
    - *Luteal Phase:* Progesterone rises, body temperature increases, and recovery slows. The algorithm should interpret "high strain" signals more conservatively and potentially reduce the intensity of endurance sessions, prioritizing steady-state aerobic work over anaerobic power.[39]
- **Symptom Logging:** Inputs for specific symptoms (cramps, fatigue) allow the system to differentiate between "training fatigue" and "cycle-related fatigue," preventing the algorithm from incorrectly lowering the user's fitness baseline due to temporary hormonal performance dips.[39]

Table 2: Daily Readiness Input Taxonomy

Input Parameter	Data Type	Source/Mechanism	Algorithmic Response Logic	Source
HRV Status	Objective	Wearable (rMSSD)	Low HRV → Reduce Intensity/Volume	29
Freshness	Subjective	Slider (-60 to +60)	Manual Offset of Training Stress Balance (TSB)	33
Soreness	Subjective	1-10 / Body Map	High Soreness → Limit Neuromuscular Load	32
Sleep Quality	Hybrid	Hours + Subjective Rating	Low Score → Increase Recovery	28

			Time advice	
Cycle Phase	Biological	Calendar / Temp Trend	Luteal → Adjust Heat/Intensity expectations	[38]
Mental Stress	Subjective	1-5 Likert Scale	High Stress → Shift to "Cognitive Ease" workouts	[36]

4. The Feedback Mechanism: Post-Activity Data Ingestion

Once the training stimulus has been applied, the cybernetic loop requires a "Check" phase. Did the user execute the plan? If not, why? And how did it feel? The "Post-Workout Survey" is the mechanism for distinguishing between a bad plan, a bad execution, or a bad day. This feedback calibrates the algorithm for the next iteration.

4.1 Rating of Perceived Exertion (RPE): The Truth Mechanism

While power meters and GPS measure *external* load, RPE measures *internal* load—the actual physiological cost of the work.

- **RPE Scales:** The most common input is the modified Borg scale (1-10).[42]
  - *1-3:* Easy / Recovery (Conversational)
  - *4-6:* Moderate / Sweet Spot (Concentration required)
  - *7-8:* Hard / Threshold (Uncomfortable)
  - *9:* Very Hard / VO2 Max (Gasping)
  - *10:* All Out (Maximal Effort / Failure).[43]
- **RPE Delta Analysis:** The algorithm calculates the delta between the *Prescribed RPE* and the *Reported RPE*.
  - *Case A (Undershooting):* Plan said RPE 8 (Threshold), User reported RPE 5 (Moderate). This suggests the user's FTP (Functional Threshold Power) or performance baseline has improved. The algorithm should trigger a **Progression Level Increase**.[44]
  - *Case B (Overshooting):* Plan said RPE 4 (Endurance), User reported RPE 8 (Hard). This indicates "Cardiac Drift" or "Decoupling," a sign of fatigue, illness, or dehydration. The algorithm should trigger a **Recovery Block** or reduce the next workout's intensity.[45]

4.2 Repetitions in Reserve (RIR): Strength Specificity

For strength training components within adaptive apps, RPE is often replaced or supplemented by RIR (Repetitions in Reserve).

- **Input Definition:** "How many more reps could you have performed with good form?" (e.g., 2 RIR).

- **Application:** RIR provides a more granular specific metric for hypertrophy and strength adaptations than general RPE. If a user consistently reports >4 RIR on "Strength" sets, the algorithm must increase the load (weight) to ensure the stimulus is effective.[46]

4.3 Qualitative Failure Analysis: The Struggle Survey

When a workout is marked as "Failed" or "Cut Short," the raw data cannot explain *why*. TrainerRoad utilizes a specific "Struggle Survey" to diagnose the root cause, which fundamentally alters the algorithmic reaction.[43]

The Struggle Taxonomy:

1. **Intensity:** "I couldn't hold the power/pace."
   - *Algorithmic Action:* This is a **Physiological Failure**. The system should lower the user's "Progression Level" for that specific energy system (e.g., de-rate VO2 Max level) but maintain other zones.
2. **Fatigue:** "I was too tired to start/finish."
   - *Algorithmic Action:* This is a **Recovery Failure**. The system should insert rest days or switch the next session to active recovery.
3. **Time/Logistics:** "I ran out of time" / "I had to answer a call."
   - *Algorithmic Action:* This is a **Null Event**. The system should *not* decrease the user's fitness levels. The missed training stress is simply redistributed.[43]
4. **Device/Technical:** "My power meter dropped out."
   - *Algorithmic Action:* **Data Scrubbing.** The system ignores the corrupted data file to prevent it from skewing the training load averages (TSS/CTL).
5. **Motivation:** "I just wasn't into it."
   - *Algorithmic Action:* **Psychological Flag.** If repeated, the system may suggest a "Variety" block or a change in training modality to restore engagement.[45]

4.4 Psychometrics: Enjoyment and Personality Matching

Adherence is the strongest predictor of long-term athletic success. Recent innovations in apps like AI Endurance and Volt Athletics include "Enjoyment" ratings to optimize for adherence.[48]

- **Enjoyment Input:** "Rate your enjoyment of this workout" (1-5 Stars).
- **Personality Correlation:** Research suggests personality traits (Extraversion vs. Neuroticism) predict enjoyment of different intensities. Extraverts may prefer high-intensity group sessions, while those with higher neuroticism may prefer steady-state solo work. By tracking enjoyment, the algorithm can "learn" the user's psychographic profile.[50]
- **Adaptation:** If a user consistently executes "Sweet Spot" intervals perfectly but rates them 1/5 for enjoyment, a sophisticated algorithm might substitute "Tempo Bursts" or "Fartlek" runs—physiologically similar but psychologically distinct—to maintain high adherence.[51]

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5. The Interface of Adaptation: UI/UX and Dynamic Adjustment

The data collection described above is useless if the system cannot effectively communicate the *result* of the adaptation to the user. The "Dynamic Plan Adjustment" UI is the bridge between the algorithm's logic and the user's behavior. It must balance automation with agency, ensuring the user feels guided, not coerced.

5.1 The "Plan Updated" Notification Architecture

When the algorithm modifies the schedule—whether due to a low readiness score, a missed workout, or a change in goal date—it must notify the user with clarity and context.

5.1.1 Pre-emptive vs. Reactive Notifications

- **Pre-emptive (Readiness-Based):** These appear upon waking or data sync.
  - *Example (Garmin):* "Rest Day Recommended. Your sleep history and HRV indicate high stress. Recovery is prioritized.".[52]
  - *Design Pattern:* This notification often uses color-coded headers (Red/Orange) to signal urgency and blocks the standard "Daily Workout" view to force the user to acknowledge the state.[41]
- **Reactive (Compliance-Based):** These appear after a missed or failed session.
  - *Example (Runna):* "We noticed you missed Tuesday's interval run. We've adjusted your Wednesday and Saturday runs to keep you on track.".[19]
  - *Design Pattern:* A "Plan Adapted" banner appears on the dashboard. Clicking it reveals a "Diff View" (Before vs. After) to show exactly which workouts moved.[20]

5.1.2 Transparency and the "Why"

Users distrust "Black Box" changes. The UI must provide the reasoning variable.

- **Opaque UI:** "Workout changed." (Low Trust).
- **Transparent UI:** "We reduced today's intensity because your HRV is 20ms below baseline and you reported 'High' leg soreness." (High Trust).[54]
- **Validation:** The Whoop interface is notable for its "Recovery" explanation, explicitly listing *which* factors (Sleep, HRV, or Sickness) drove the score down, empowering the user to address the specific root cause.[28]

5.2 Managing Missed Workouts: The Adjustment Logic

The UI must handle non-compliance without inducing guilt. The "Missed Workout" flow is a critical retention point.

- **User Choice:** Platforms like Runna allow users to choose the adaptation strategy.
  - *Option A: Reschedule.* "Shift my plan forward." (Good for illness/injury breaks).
  - *Option B: Skip.* "Delete this run and recalculate." (Good for busy work weeks). The algorithm then redistributes the critical volume to future sessions or accepts a

slightly lower fitness progression.[20]

- **Algorithm-Led Adaptation:** TrainAsONE takes a more automated approach, silently recalculating the *probability* of hitting the race goal. If too many workouts are missed, the UI might prompt the user to "Re-evaluate Goal Time" based on the new reduced training volume.[18]

5.3 Chat Interfaces and LLM Integration

The cutting edge of adaptive UI is the integration of Large Language Models (LLMs) to facilitate natural language coaching. AI Endurance demonstrates this with a chatbot that allows users to query the algorithm logic directly.[48]

- **Scenario:** A user is unsure about a workout.
- **User Query:** "I feel tired today, can I skip the intervals?"
- **System Response:** "Your HRV is normal, but your subjective readiness is low. I can swap the VO2 Max intervals for a 45-minute Zone 2 recovery ride to maintain aerobic volume without the neural stress. Would you like to apply this change?"
- **Impact:** This interaction mimics the "Coach-Athlete" negotiation, significantly increasing user trust and adherence compared to a silent, automated change.[55]

5.4 The Coefficient of Variation (CV) Visualization

To prevent user panic over minor data fluctuations, advanced UIs visualize the **Coefficient of Variation (CV)**.

- **Concept:** A 5% drop in readiness might be normal noise for User A (High CV) but a sign of illness for User B (Low CV).[1]
- **UI Implementation:** Oura and Whoop use "Baseline Ranges" (shaded areas on graphs). The user is only notified if the metric falls *outside* this normal variance range. This "Signal-to-Noise" filtering prevents alert fatigue and focuses the user on meaningful deviations.[57]

Table 3: Dynamic Adjustment UI Best Practices

UI Component	Function	Best Practice Example Text	Source
Readiness Alert	Pre-training guidance	"Rest Day Recommended. High acute load detected."	41
Adaptation Banner	Notify of schedule change	"Plan Updated: Tuesday's intervals moved to Wednesday."	20
Struggle Survey	Diagnose failure cause	"Why did you struggle? [Intensity][Fatigue]"	43
Chat Assistant	Natural language query	"How am I looking ahead of tomorrow's race?"	48

Insight Card	Contextual education	"Your Luteal phase may increase RPE today. Stay cool."	[38]

6. Synthesis and Future Architectures

The evolution of adaptive training algorithms is a convergence of objective precision and subjective context. The analysis of current best practices reveals that the most effective systems are those that treat **User Input Parameters** not as secondary metadata, but as the primary control signals for the periodization engine.

The ideal architecture for a next-generation adaptive system must be built on four pillars:

1. **Granular Initialization:** A Goal Wizard that captures the full dimensionality of the event (Terrain, Priority) and the user (Constraints, Risk Appetite).
2. **Holistic Readiness:** A daily loop that weights biometric data (HRV, Cycle Phase) with direct human input (Freshness, Soreness) to determine capacity.
3. **Diagnostic Feedback:** A post-activity survey that distinguishes between physiological failure and logistical failure, preventing false negatives in fitness tracking.
4. **Transparent Adaptation:** A UI that explains the *cause* of every plan change, utilizing natural language and visual data ranges to build trust.

As wearable technology evolves to include continuous glucose monitoring (CGM) and real-time core temperature sensing, the volume of objective data will explode. However, the value of the **Subjective Input** will only increase. In a sea of data, the user's voice—their motivation, their pain, and their perception—remains the most powerful signal for determining not just what an athlete *could* do, but what they *will* do. The future of training is not just adaptive; it is conversational.

7. Conclusions and Recommendations for Algorithm Design

Based on the synthesis of the 158 research snippets analyzed, the following actionable recommendations are provided for the design of adaptive training software:

1. **Mandate SMART Goal Inputs:** Do not allow vague goals. Force users to define "A" races and specific time/completion metrics to anchor the ATP.[4]
2. **Implement a "Struggle Survey" Logic:** Never interpret a missed or failed workout without asking "Why?" Differentiate between physiological limits (lower intensity) and logistical limits (ignore data).[43]
3. **Integrate Women's Health by Default:** Cycle tracking should be a core parameter, not an add-on. Algorithms must adjust intensity expectations based on the Follicular/Luteal phase metabolic shifts.[38]
4. **Visualize the "Why":** Avoid black-box adaptations. Every plan change must be

accompanied by a natural language explanation citing the specific input (e.g., "Due to low sleep score...") that triggered it.[48]

5. **Use RPE as a Validator:** Always collect RPE. Use the delta between *Planned* vs. *Actual* RPE to auto-correct FTP and training zones without improved testing.[23]
6. **Prioritize Enjoyment for Adherence:** Track workout enjoyment. If a user hates a specific modality, the algorithm should seek physiological equivalents that yield higher enjoyment scores to prevent churn.[49]

By implementing these parameters, developers can move beyond static "spreadsheets in an app" to create truly responsive, bio-digital coaching ecosystems that adapt to the complex reality of the human athlete.

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