Time-Intensity Coupling for Training Load Analysis

1. Why raw time is misleading:

* Raw duration ignores intensity: 1 hour of recovery spin ≠ 1 hour of threshold intervals.
* It also ignores athlete fitness: 1 hour for a pro may be easy, while for a beginner it can be massive load.

1. Time–Intensity Coupling:

* Most training load metrics (TRIMP, TSS, Garmin Load) use a weighted time approach.
* Banister TRIMP (classic): TRIMP = Duration (min) × ΔHR × y where ΔHR = HRR fraction and y = exponential weight for intensity.
* Zone-based TRIMP: Each minute in Zone 1, 2, … gets a fixed multiplier (e.g., Zone 1 = 1, Zone 2 = 2, …). Training Load = Σ(time in zone × zone weight).
* TSS (TrainingPeaks): Normalizes time against Functional Threshold Power (FTP) or pace equivalent, so 60 min at FTP = 100 TSS.

1. What we can do for your project:

* Instead of treating time as a raw feature, normalize it by intensity.
* HRR-weighted time: Eff. duration = Σ(time in zone × zone weight).
* Exponentially weighted TRIMP time: Minutes spent at higher intensities grow disproportionately, similar to Garmin’s EPOC-based load.

1. The key idea:

* Training load is not additive in time alone; it’s additive in time × intensity.
* Like heart rate, duration needs scaling to accurately reflect physiological cost.