

This document serves as a high-level overview of dataset generation. For detailed derivations, coefficient tables, and empirical parameter justification, see [ATHLETE\\_READINESS\\_TRANSFORMER\\_COMPREHENSIVE.pdf](#)

# SYNTHETIC DATASET: ATHLETE READINESS PROJECT

## OVERVIEW

This file contains the information required to reproduce the 17 features and 3 corresponding labels for all 100 athletes over 150 days. Reproduction of data can be executed using a commercial LLM (e.g. ChatGPT). Below are the formulas used to calculate next-day data.

Formulas are based on physiologically realistic relationships between physiology, sleep, training, and recovery. Each feature follows within- and between-athlete variability inspired by empirical datasets (PPG-DaLiA, Sleep-EDF).

- sinDOWt and cosDOWt are markers to enable weekly patterns to emerge by associating a combination of their values to a particular day.
- $\mu$  contributes to individuality in a particular metric (interindividual variation).
- Lag (hysteresis) and noise are also included.

## FEATURES

### HRV and RHR (physiology)

HRV dynamics (z-scored)

$$\begin{aligned} HRV_{z,t} = & \rho_h HRV_{z,t-1} - a_1 Load_{z,t-1} - a_2 ACWR_t - a_3 RHR_{z,t-1} \\ & + b_1 SleepEff_{z,t-1} + b_2 SleepDur_{z,t-1} \\ & - a_4 Load_{z,t-2} - a_5 ACWR_{t-1} \\ & + e_1 (Load_{z,t-1} \times SleepEff_{z,t-1}) + \epsilon_t \end{aligned}$$

RHR dynamics (z-scored)

$$\begin{aligned} RHR_{z,t} = & \rho_r RHR_{z,t-1} + c_1 Load_{z,t-1} + c_2 ACWR_t + c_3 (-HRV_{z,t-1}) \\ & - d_1 SleepEff_{z,t-1} - d_2 SleepDur_{z,t-1} \\ & + c_4 Load_{z,t-2} + c_5 ACWR_{t-1} \\ & + e_2 (Load_{z,t-1} \times SleepEff_{z,t-1}) + \eta_t \end{aligned}$$

### Sleep Duration and Sleep Efficiency (sleep)

Sleep duration

$$\begin{aligned} Dur_{z,t} = & \rho_d Dur_{z,t-1} + \gamma_1 Def_{t-1} + \gamma_2 Load_{z,t-1} - \gamma_3 ACWR_t \\ & + \kappa_{d1} \sin DOW_t + \kappa_{d2} \cos DOW_t \\ & + \gamma_4 (Load_{z,t-1} \times Def_{t-1}) + \epsilon_t^{(d)} \end{aligned}$$

Sleep efficiency

$$\begin{aligned} Eff_{z,t} = & \rho_e Eff_{z,t-1} - \beta_1 Load_{z,t-1} - \beta_2 ACWR_t - \beta_3 Fatigue_{z,t-1} \\ & + \beta_4 Def_{t-1} + \kappa_{e1} \sin DOW_t + \kappa_{e2} \cos DOW_t \\ & + \beta_5 (Load_{z,t-1} \times Eff_{z,t-1}) + \epsilon_t^{(e)} \end{aligned}$$

Note:  $Def_{t-1}$  is an individual's sleep deficit determined by yesterday's sleep. Calculated using following formula:

$$Def_{t-1} = \max\left(0, \frac{TargetDur_i - Dur_{raw,t-1}}{SD_{Dur,i}}\right)$$

### Rating of Perceived Exertion (training)

$$\begin{aligned}
RPE_{z,t}^{(i)} = & \rho_p^{(i)} RPE_{z,t-1}^{(i)} + \phi_1^{(i)} Load_{z,t-1}^{(i)} + \phi_2^{(i)} ACWR_{t-1}^{(i)} + \phi_3^{(i)} Fatigue_{z,t-1}^{(i)} \\
& - \phi_4^{(i)} Readiness_{t-1}^{(i)} - \phi_5^{(i)} SleepEff_{z,t-1}^{(i)} - \phi_6^{(i)} SleepDur_{z,t-1}^{(i)} \\
& + \lambda_1^{(i)} \sin DOW_t + \lambda_2^{(i)} \cos DOW_t \\
& + \phi_7^{(i)} (Fatigue_{z,t-1}^{(i)} \times (1 - Readiness_{t-1}^{(i)})) + \mu_{RPE}^{(i)} + \epsilon_t^{(i,p)}
\end{aligned}$$

### Fatigue and Soreness (recovery)

$$\begin{aligned}
Fatigue_{z,t}^{(i)} = & \rho_f^{(i)} Fatigue_{z,t-1}^{(i)} + \psi_1^{(i)} Load_{z,t-1}^{(i)} + \psi_2^{(i)} ACWR_{t-1}^{(i)} - \psi_3^{(i)} SleepDur_{z,t-1}^{(i)} \\
& - \psi_4^{(i)} SleepEff_{z,t-1}^{(i)} - \psi_5^{(i)} Readiness_{t-1}^{(i)} + \psi_6^{(i)} RHR_{z,t-1}^{(i)} - \psi_7^{(i)} HRV_{z,t-1}^{(i)} \\
& + \psi_8^{(i)} \sin DOW_t + \psi_9^{(i)} \cos DOW_t \\
& + \psi_{10}^{(i)} (Load_{z,t-1}^{(i)} \times (1 - Readiness_{t-1}^{(i)})) + \mu_{Fatigue}^{(i)} + \epsilon_t^{(i,f)}
\end{aligned}$$

$$\begin{aligned}
Soreness_{z,t}^{(i)} = & \rho_s^{(i)} Soreness_{z,t-1}^{(i)} + \omega_1^{(i)} Load_{z,t-1}^{(i)} + \omega_2^{(i)} ACWR_{t-1}^{(i)} + \omega_3^{(i)} Fatigue_{z,t-1}^{(i)} \\
& - \omega_4^{(i)} SleepDur_{z,t-1}^{(i)} - \omega_5^{(i)} SleepEff_{z,t-1}^{(i)} - \omega_6^{(i)} Readiness_{t-1}^{(i)} \\
& + \omega_7^{(i)} \sin DOW_t + \omega_8^{(i)} \cos DOW_t \\
& + \mu_{Soreness}^{(i)} + \epsilon_t^{(i,s)}
\end{aligned}$$

Note that the remaining 10 features are derived from the above features (e.g. InternalLoad is simply RPE  $\times$  SessDuration).

### The remaining 10 features:

- HRV Delta (*change from yesterday*)
- RHR Delta (*change from yesterday*)
- Session Duration
- Internal Load
- Acute Load
- Chronic Load
- ACWR
- DOW\_sin
- DOW\_cos
- Previous CRI (*yesterday*)

## LABELS

### Continuous Readiness Index (CRI)

$$\text{Index}_t = \sigma \{ +w_1 \text{HRV}_z - w_2 \text{RHR}_z + w_3 \text{SleepEff}_z - w_4 \text{ACWR} + w_5 (\text{HRV}_z \times \text{SleepEff}_z) - w_6 (\text{ACWR} \times \text{RHR}_z) + \text{lags} + \epsilon \}$$

The CRI will produce a value between 0 and 1, where 0 signals significant fatigue and 1 signals optimal physiological state.

The **remaining 2 labels** are derived from CRI:

- ReadyBin: 0 if  $CRI < 0.5$ ; 1 if  $CRI \geq 0.5$
- ReadyOrd: 0 if  $0 \leq CRI < 0.2$  | 1 if  $0.2 \leq CRI < 0.4$  | 2 if  $0.4 \leq CRI < 0.6$  | 3 if  $0.6 \leq CRI < 0.8$  | 4 if  $0.8 \leq CRI \leq 1$

## FILE CONTENTS

- `readiness_timeseries.csv` - Full simulated dataset ( $100 \times 150 = 15,00$  rows)
- `schema.json` - Column names, data types, and units
- `normalization_stats.json` - Athlete baselines and within-athlete SDs
- `simulation_config.json` - Simulation parameters and random seeds
- `splits_loao.json` - Leave-One-Athlete-Out (LOAO) cross-validation splits