# Normalization of Distance: Exponential Baseline Ratio (ACWR-style)

## 1. The intuition

Athletes don’t respond to absolute distance/time/load but to how today compares to what they’re used to. The ratio of short-term load (acute) to long-term load (chronic) captures this. If today (or this week) is way higher than your chronic baseline, injury/fatigue risk rises. If it’s too low, you may detrain.

## 2. Definition

ACWR\_t = Acute workload\_t / Chronic workload\_t

- Acute workload: recent load, sensitive to spikes (e.g. 7-day EWMA).  
- Chronic workload: baseline fitness load, smooth (e.g. 28-day EWMA).

## 3. Why exponential moving averages (EWMA)?

Classical ACWR used simple moving averages (SMA), e.g.:  
- Acute = mean distance in past 7 days  
- Chronic = mean distance in past 28 days  
  
But SMA has hard cutoffs and weights each day equally.  
EWMA fixes this by:  
- Giving more weight to recent sessions (yesterday > last week).  
- Still smoothing over the whole window.  
- Making the measure more sensitive to recent changes.

Formula for EWMA:  
EWMA\_t = α \* x\_{t-1} + (1-α) \* EWMA\_{t-1}, with α = 2/(span+1).

## 4. Example in distance

Let’s say your runs over 10 days were [5, 6, 8, 12, 15, 7, 6, 10, 20, 5] km.  
  
- Acute (7-day EWMA) might sit around 9–10 km.  
- Chronic (28-day EWMA) might sit around 7 km.  
- If today you run 20 km, then: ACWR ≈ 9.5 / 7.0 ≈ 1.35  
  
That says: 'This week is 35% harder than your long-term baseline.'

## 5. How to interpret

- < 0.8 → Undertraining (too easy vs baseline).  
- 0.8 – 1.3 → “Sweet spot”: balanced training vs history.  
- > 1.5 → Spike in load; potential fatigue/injury risk.  
  
(These thresholds come from Gabbett et al., though they’re debated — best use them as guides, not strict cutoffs.)

## 6. Why it’s good for your use case

- It normalizes distance (or time, or TRIMP) against your own history.  
- It’s relative and personalized, not absolute.  
- It captures spikes that simple %max HR or per-session TSS might miss.  
- It can be computed for any metric: distance, duration, TRIMP, TSS, Garmin load, etc.

## 7. Python snippet (distance example)

def compute\_acwr(df, span\_acute=7, span\_chronic=28):  
 out = df.sort\_values('Date').copy()  
 d = out['Distance [km]']  
  
 # shift(1) → no leakage (only past info)  
 acute = d.shift(1).ewm(span=span\_acute, adjust=False).mean()  
 chronic = d.shift(1).ewm(span=span\_chronic, adjust=False).mean()  
  
 out['ACWR'] = (acute / chronic).replace([np.inf, -np.inf], np.nan)  
 return out