# Monitoring Training Adaptation: A Scoping Review of the Relationship Between Self-Reported Subjective Variables & Resting Heart Rate Variability (vmHRV) in Adult Athletes


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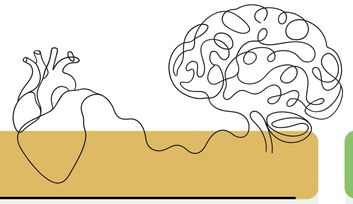


## Introduction

In athletes, the **balance between training load and recovery** is key for adaptation, performance, and injury prevention. This balance is complex, and several markers have been proposed to monitor it (1). Among them, **vagally-mediated heart rate variability (vmHRV)** -particularly the Root Mean Square of Successive Differences (RMSSD)- is an established physiological indicator. Additionally, **self-reported subjective variables (SVs)**, such as sleep quality, muscle pain, and mood, are also widely used.

Recently, researchers and coaches have highlighted the value of incorporating both types of markers to assess the states of well-being, fatigue, and performance in athletes (2).

### Goal of the review

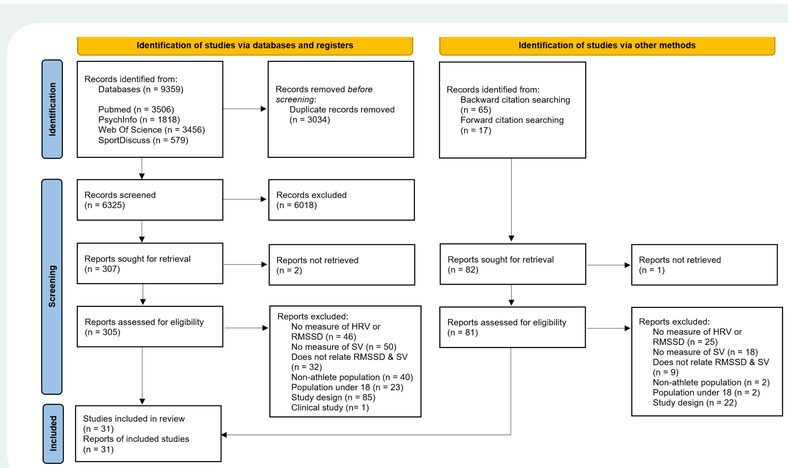
Despite wide usage of RMSSD-based vmHRV & SVs, their relationship remains unclear. This review aims to:

- **Synthesize** evidence on the **correlations between RMSSD & SVs.**
- **Evaluate measurement methods** used across studies.
- **Provide recommendations** for monitoring protocols.

## Method

**A scoping review** was conducted following PRISMA-ScR guidelines.

- **Databases:** PubMed, PsychINFO, Web of Science, SportDiscus (May 2025)
- **Inclusion criteria:** Observational studies with adult athletes, reporting correlations between RMSSD-based vmHRV and SVs, in English.
- **Exclusion**: Interventions, reviews, non-peer-reviewed, clinical/animal studies.
- **Quality appraisal:** Joanna Briggs Institute (JBI) and Cohen's κ (κ = 0.85–1.00).



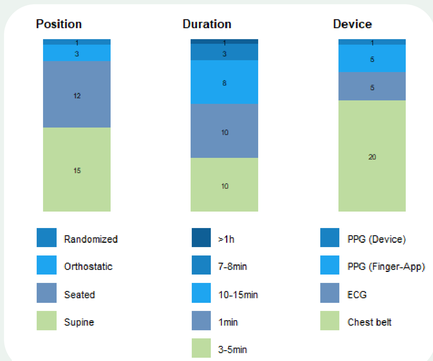

## Results (*n* = 31 articles)

### 1. Sample Characteristics

- **Total athletes:** 514 (age 23.5 ± 4.2)
- **Gender:** females-only (*n* = 12), male-only (*n* = 8), mixed (*n* = 8)
- **Sport types:** individual & team. A variety, for e.g. football (*n* = 8), waterpolo (*n* = 1), swimming (*n* = 4), cycling (*n* = 3), running (*n* = 2), CrossFit (*n* = 1), dance (*n* = 1)
- **Athletic level:** 20 elite, 7 competitive, 1 recreational

### 2. Methodological Observations

- **vmHRV**: the **Figure** presents the devices, body positions & duration of recordings used to measure RMSSD.
- **SVs:** 20 different types (most common: fatigue, *n* = 13; perceived stress, *n* = 14), collected using 19 different questionnaires (e.g. RESTQ and TQR) and 4 Likert scales.
- **Timing:** Only 58% of studies measured vmHRV & SVs simultaneously. Mostly upon waking up, in the morning.
- **Frequency:** varied, from single measures to daily measures for 3+ months.




### 3. Correlations Between vmHRV and SVs:

SVs were classified into 3 categories:

- **Fatigue & Recovery:** RMSSD mostly correlated positively with perceived recovery (53%), negatively with fatigue (56%) & muscle soreness (40%).
- **Psychological States:** Inconsistent/weak associations.
- **Sleep-Related:** Mostly no clear correlation. Sleep quality & RMSSD (+27%).

**Figure 2:** Correlations between vmHRV and SVs

| | | Positive | Negative | No association |
|---|---|---|---|---|
| Fatigue and Recovery Indicators | Burnout | - | - | 2 |
| | Energy levels | - | - | 1 |
| | Fatigue | 2 | 9 | 5 |
| | Muscle soreness | - | 4 | 6 |
| | Perceived recovery | 9 | - | 8 |
| | Recovery-stress | - | - | 1 |
| | Risk of overuse | - | 1 | - |
| | Stress Tolerance | - | - | 1 |
| Psychological States | Anxiety | 1 | 5 | 6 |
| | Body Awareness | - | - | 1 |
| | Mood | 2 | 2 | 4 |
| | Perceived stress | 4 | 8 | 9 |
| | Wellbeing | 1 | 2 | 6 |
| Sleep-related Variables | Sleep quality | 4 | 2 | 9 |
| | Sleepiness | - | - | 1 |

**! The variety of methodologies used to measure vmHRV & SV reduced the comparability of results.**

## Conclusions

**Overall: The relationship between vmHRV and SVs is variable and context-dependent, influenced** by factors such as individual training status and measurement inconsistencies. → The review supports the integration of both physiological and psychological metrics for a more complete understanding of training adaptation.

**Recommendations,** given the growing number of studies across different sports:

- **Use simultaneous measurements** of resting vmHRV & SVs
- **Standardize protocols**, including timing, posture, devices, and SVs definitions
- **Interpret data against individual baselines,** not population norms
- **Promote longitudinal, multi-dimensional monitoring** over single-point metrics

Download guidelines: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