



THE IMPORTANCE OF ASSESSING THE AUTONOMIC NERVOUS SYSTEM RESPONSE THROUGH HEART RATE VARIABILITY (HRV) IN PATIENTS UNDERGOING COMPREHENSIVE MEDICAL RECOVERY TREATMENT

Liliana – Elena Stanciu^{1,2} , Andreea – Bianca Uzun^{1,2,3}, Andreea – Dalila Nedelcu^{1,2,3}, Diana – Alexia Strîmbeschi¹,
Luca – Mircea Neamțu¹ , Andreea – Ioana Bîlici¹ , Mădălina Gabriela Iliescu^{1,2,3}

1 Techirghiol Balneal and Rehabilitation Sanatorium, Romania

2 Department of Physical Medicine and Rehabilitation, Faculty of Medicine, “Ovidius” University of Constanța, Romania

3 Medical Doctoral School, Faculty of Medicine, “Ovidius” University of Constanța, Romania

I have no actual or potential conflict of interest in relation to this program/presentation.

IHHT



Figure 1 – Intermittent hypoxia-hyperoxia therapy

Intermittent hypoxia-hyperoxia therapy (IHHT) involves the controlled alternation of hypoxic hyperoxic intervals and is being studied as an adjunctive method in recovery.

Proposed mechanisms include the stimulation of adaptive responses to hypoxia, the influence on oxidative metabolism, and possible effects on cardiovascular function, inflammation and autonomic regulation.

Current evidence suggests that IHHT is **promising and generally well tolerated**, but the literature still highlights the need for more standardised protocols and larger clinical trials.

HRV (heart rate variability) can be viewed as a **functional biomarker of treatment adaptation**, useful for assessing the autonomic response in medical recovery.

HRV: definition and clinical relevance

- **Heart rate variability (HRV)** represents the variation in the intervals between successive sinus heartbeats and is a non-invasive method of assessing cardiac autonomic regulation.
- HRV has **diagnostic, prognostic and monitoring** value, and is used to assess the sympathetic-vagal balance and the biological response to stress or treatment.
- In this study, **SDNN** and **HTI** were analysed as markers of overall variability, whilst **RMSSD** and **pNN50** were analysed as predominantly vagal/parasympathetic indicators.
- **The Baeovsky stress index** can provide information on sympathetic load, but its interpretation must be approached with caution, as it is less standardised than classic HRV indices.



Figure 2 – The device using THHI



Figure 3 – Patient undergoing HRV testing



Figure 4 – Electrode placing during HRV testing

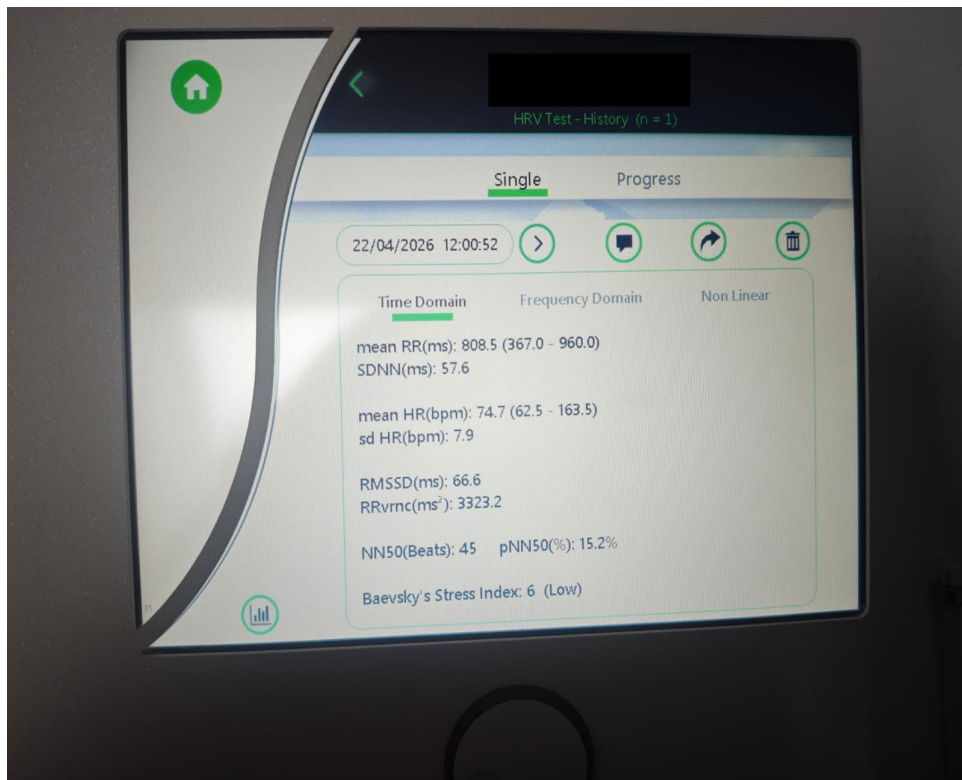


Figure 5 – HRV parameter analysis



Figure 6 – R-R interval distribution during assessment

- **HTI (HRV Triangular Index)**
 - the ratio of the total number of heartbeats to the most frequent duration
- **SDNN (Standard Deviation of NN Intervals)**
 - the total variability of the heart rate
 - the body's general ability to *adapt* to stress and its health reserve
- **RMSSD (Root Mean Square of the Sum of Squares of Differences between Adjacent NN Intervals)**
 - the main indicator of parasympathetic (vagal) activity
 - the heart's capacity for *recovery and the degree of cardiovascular protection*
- **pNN50 (%)**
 - the percentage of consecutive beats that vary by more than 50 ms
 - reflects short-term cardiac stability
- **NN50 (beats)**
 - the absolute number of consecutive intervals differing by more than 50 ms
 - *the frequency* of rapid rhythm *variability*
- **Baevsky Stress Index (SI)**
 - measures the stress on the body's regulatory systems
 - level of *biological stress*; the higher the value, the greater the effort the heart exerts to maintain balance

HRV in medical recovery

- HRV may be useful at **admission** → for autonomic stratification
→ and for **reassessment** to monitor adaptation to treatment
- Comprehensive balneophysical-kinetic treatment:
→ **cardiovascular, muscular, metabolic and neurovegetative** stimulation
→ HRV can capture the autonomic response to these interventions
- Impact of therapeutic stress → **transient increase in sympathetic activation**
- Post-recovery adaptive effect → **parasympathetic reactivation:**
 - ✓ ↑ RMSSD may suggest a more favourable adaptation
 - ✓ ↓ persistent HRV → overexertion/incomplete recovery
- HRV → **personalisation of therapeutic dosage**
 - ▶ but must be interpreted in conjunction with the clinical picture and the patient's symptoms

MATERIALS AND METHODS

A longitudinal, analytical **observational study** was conducted on a **cohort of 30 patients** admitted for medical recovery, who were assessed on admission and on discharge. The study report followed the STROBE principles for observational studies.

The cohort included patients with musculoskeletal disorders, aged 46 to 86 years (mean 61.1 ± 9.3 years), of whom 25 were women and 5 were men. Twenty-five patients were from urban areas and 5 from rural areas. Associated cardiovascular disease was present in 17 patients.

INCLUSION CRITERIA

- admission for medical recovery in the context of a musculoskeletal condition,
- age >18 years
- participation in the comprehensive therapeutic programme, which included intermittent hypoxia-hyperoxia therapy, availability of HRV assessment at both admission and discharge
- availability of complete data in the study database

EXCLUSION CRITERIA

- absence of one of the two HRV measurements, incomplete or uninterpretable data, HRV recordings of inadequate quality
- the presence of heart rhythm disorders that could have significantly affected the HRV analysis
- clinical instability during hospitalisation and the inability to complete the treatment protocol

Admission → demographic and clinical data:

- age, gender, area of residence, primary diagnosis, associated cardiovascular disease and type of resistance

Patients underwent the department's comprehensive medical recovery programme:

→ balneophysical-kinetic therapy, including intermittent hypoxia-hyperoxia therapy (IHHT), in accordance with the institutional protocol

Given the multisystemic effects of these interventions, including their impact on autonomic regulation

→ HRV was used as a tool for monitoring cardiovascular safety and treatment response

HRV was assessed at admission and discharge by analysing the following indices:

→ HTI, SDNN, RMSSD, NN50, pNN50, and the Baevsky stress index

- SDNN and HTI provide information on overall variability
- RMSSD and pNN50 → vagal activity
- Baevsky index → sympathetic load, with the caution required due to incomplete standardisation

The data were analysed comparatively between admission and discharge, using descriptive statistics and tests for paired samples

DEMOGRAPHIC DATA

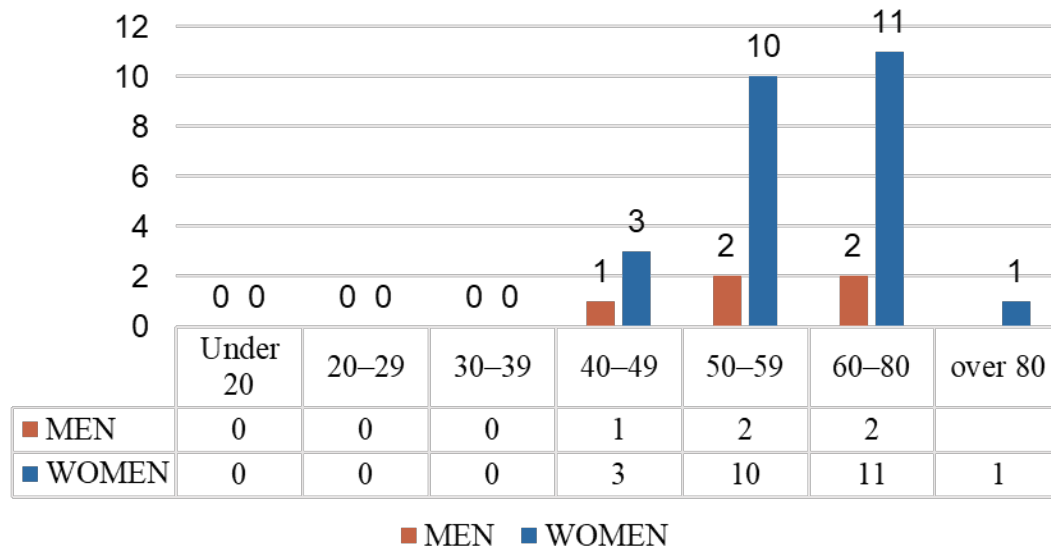


Figure 7 – Distribution by gender and age

- **The mean age of the study cohort was 61.1 ± 9.3 years, ranging from 46 to 86 years.** This indicates that the cohort consisted mainly of **middle-aged to elderly** patients, which is consistent with the nature of degenerative musculoskeletal conditions, which are more commonly found in these age groups.
- The gender distribution showed a clear predominance of women in the study group, with **25 female patients (83.3%)** compared with **5 male patients (16.7%)**.

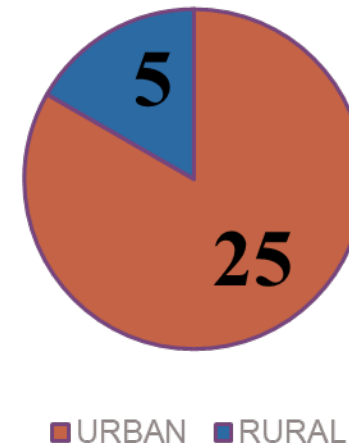


Figure 8 – Place of origin

- Regarding the area of residence, the majority of patients came from urban areas, namely **25 cases (83.3%)**, whilst **5 patients (16.7%)** came from rural areas.

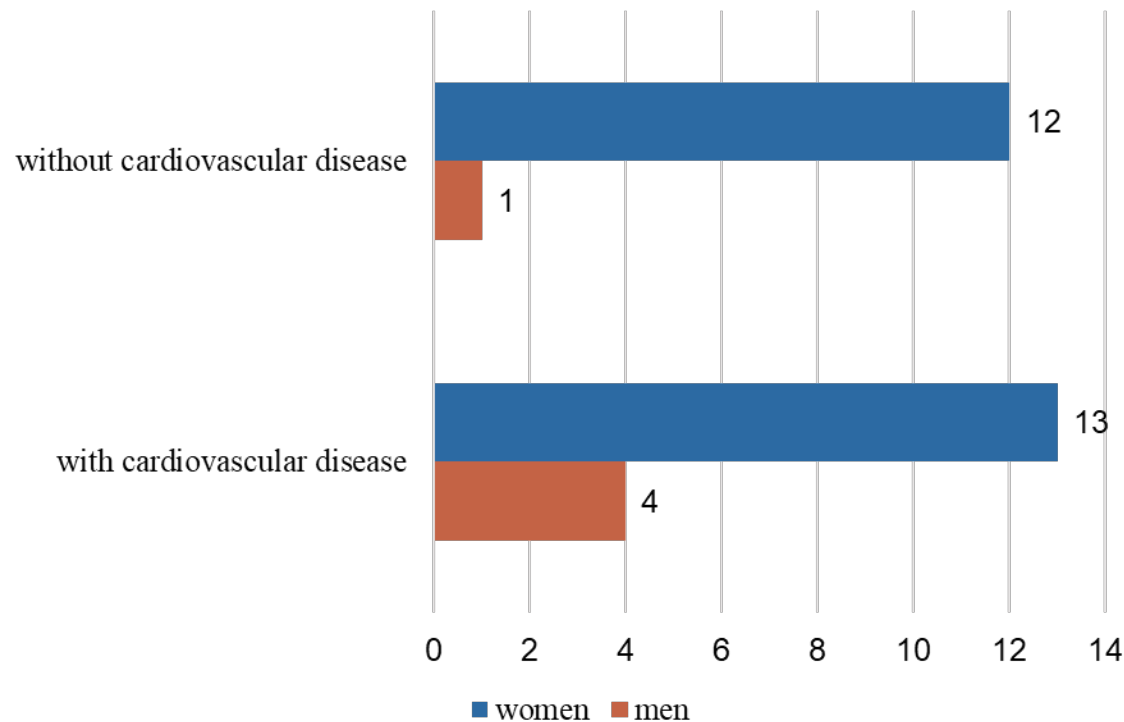


Figure 9 – Cardiovascular comorbidities

Associated cardiovascular disease was present in **17 of the 30 patients (56.7%)**, indicating that more than half of the cohort had comorbidities with a potential impact on cardiac autonomic regulation. Of these patients, **13 were women** and **4 were men**, whilst the group without associated cardiovascular pathology included **12 women** and **1 man**. This distribution should be interpreted in the context of the overall female predominance within the study cohort.

Classification of autonomous profiles in the study sample

A. PARASYMPATHETIC profile (Adapted):

- good autonomic reserve, optimal recovery capacity

B. SYMPATHETIC profile (Stress):

- sympathetic dominance, reactive/vulnerable patient

C. UNSTABLE Profile:

- autonomic rigidity, very low reserve

D. FRAGILE PARASYMPATHETIC Profile (Unclassifiable):

- organism with depleted reserves, attempting to maintain a parasympathetic balance
- very low energy level

Classification of autonomous profiles in the study sample

Parasympathetic profile (adapted):

- RMSSD ↑
- pNN50 ↑
- NN50 ↑
- SDNN normal / ↑
- SI ↓

Sympathetic profile:

- RMSSD ↓
- pNN50 ↓
- NN50 ↓
- SDNN normal / slightly ↓
- SI ↑

Unstable profile:

- RMSSD ↓
- pNN50 ↓
- NN50 ↓
- SDNN ↓
- SI ↑↑

Parasympathetic profile (fragile):

- Most parameters at the lower limit, without aggressive sympathetic dominance

Parameter

Normal value

RMSSD (ms)	> 30
pNN50 (%)	> 3
NN50 (beats)	> 50
SDNN (ms)	> 50
Baevsky Index (SI)	50 – 150

Distribution of the cohort according to autonomous adaptation profiles

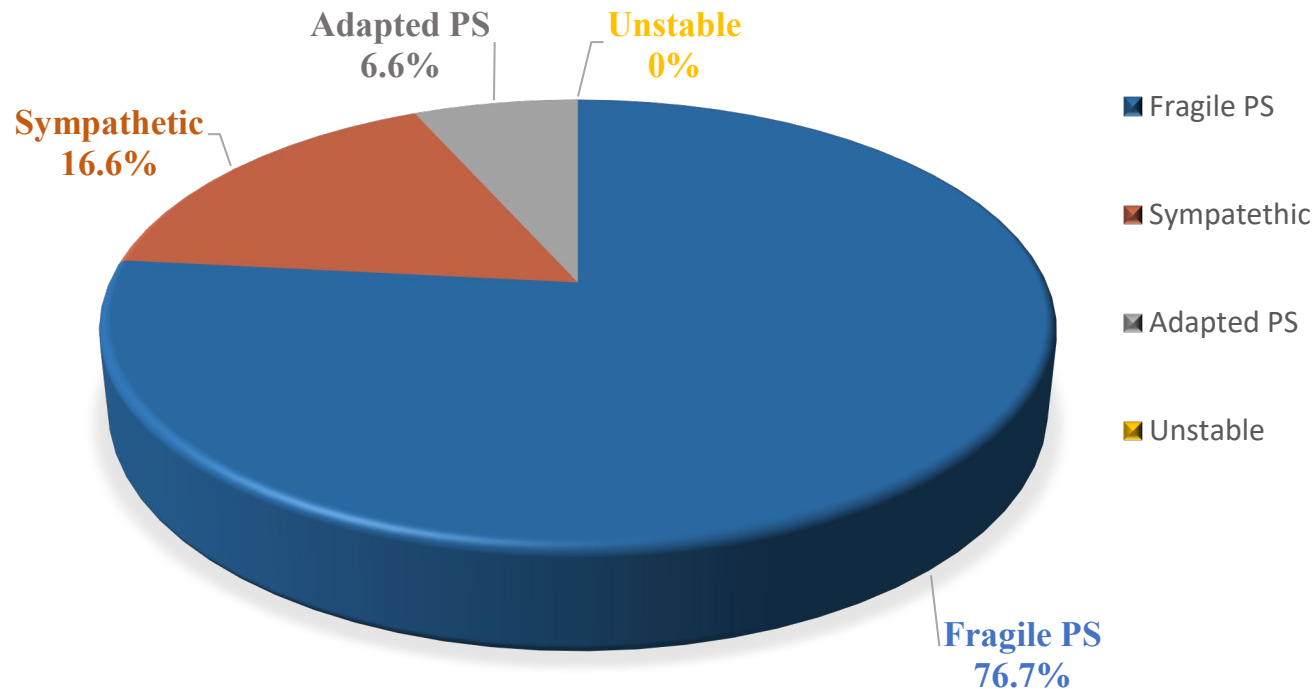
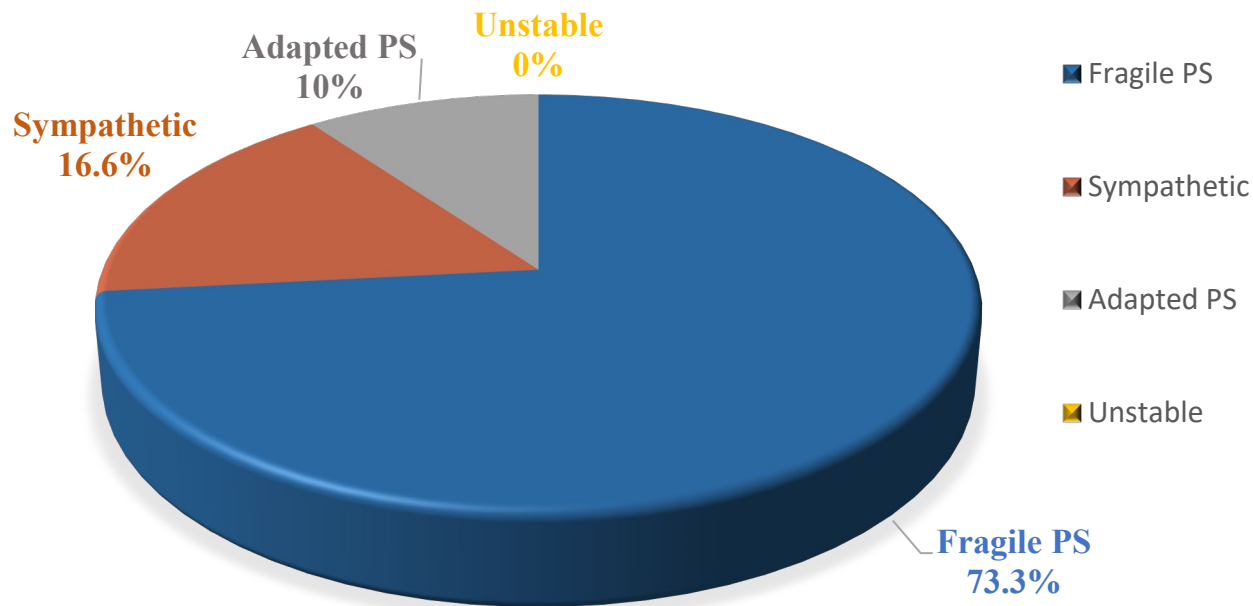


Figure 10 – Distribution of the cohort according to autonomous adaptation (admission)

- The majority of patients (**76.7%**) exhibit **increased autonomic vulnerability (fragile PS)** → due to reduced functional reserves (low pNN50 and RMSSD)
- The low percentage of patients with an **adapted parasympathetic profile (6.6%)** confirms the need for a medical recovery protocol focused on rebalancing the nervous system and reducing cardiovascular risk

Distribution of the cohort according to autonomous adaptation profiles



- Over **70%** of the cohort exhibits a **Fragile Parasympathetic Profile**, characterised by low overall variability and limited adaptive reserves
- The absence of the **Unstable Profile (0%)** confirms the safety of the used therapeutic protocol
- There was a *slight increase* in the **Adapted Parasympathetic Profile**

Figure 11 – Distribution of the cohort according to autonomic adaptation profiles (discharge)

Trends in the Baevsky index

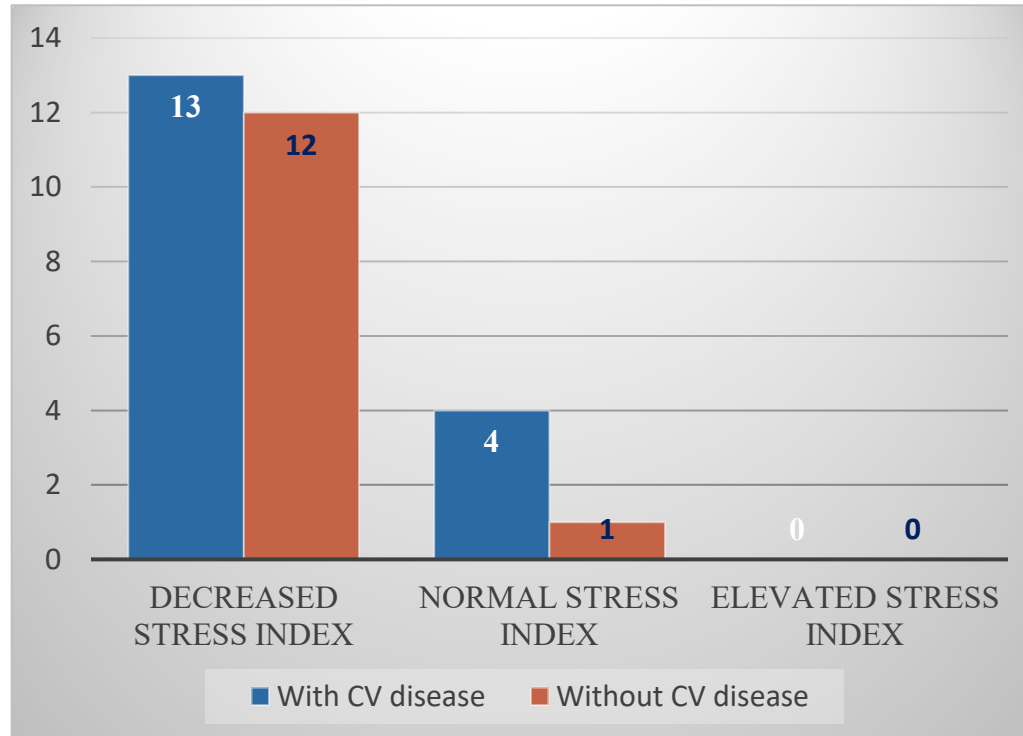
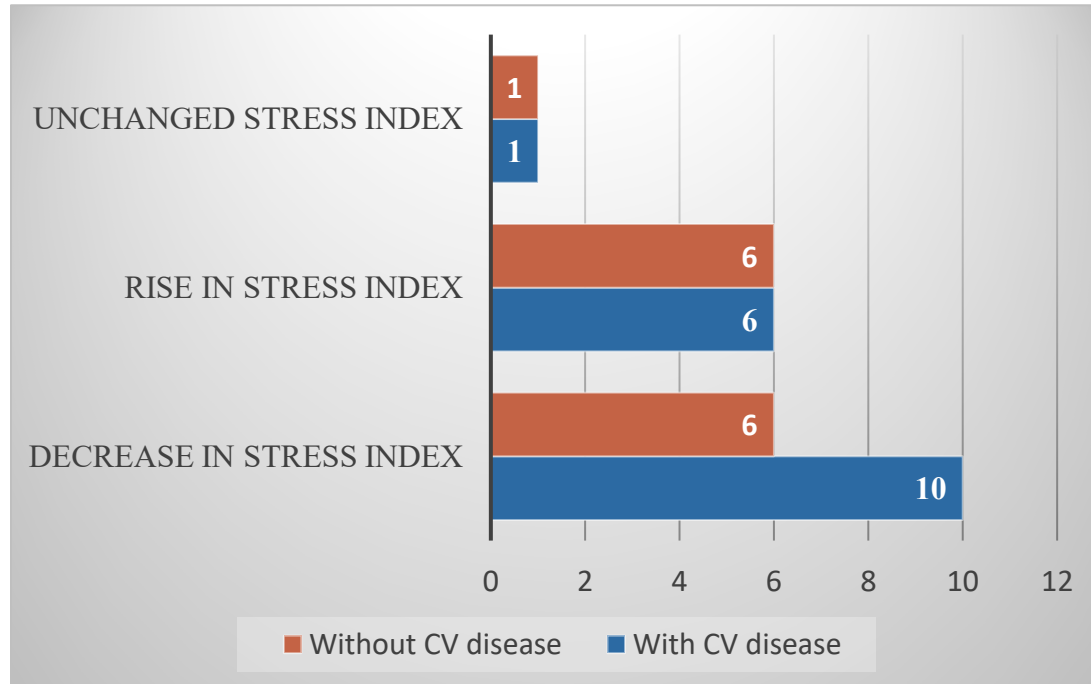


Figure 12 – Stress index in relation to cardiovascular pathology (admission)

- Specificity: the highest values of autonomic stress occur **exclusively** in the cardiac subgroup
- Safety of the study group: baseline values were below the critical threshold (<150)
- 83% of the patient cohort (25/30 patients) started with a stress index $< 50 \rightarrow$ preserved adaptive reserve

Trends in the Baevsky index



- Patients with the greatest reductions in the stress index had associated **cardiovascular pathology** → the safety of complex medical recovery treatment for this vulnerable subgroup (associated CV pathology)

Figure 13 – Evolution of the stress index in relation to cardiovascular pathology (discharge)

Trends in Global Variability Indices

HTI (Triangular HRV Index)

- Variable response to treatment: 14 out of 30 patients (46.66%) showed **an increase** in the index, 2 patients (6.66%) showed **unchanged** values, and the remaining 14 patients had **decreased** values

➤ Notable positive developments:

- Patient 9: **53 → 116**
- Patient 12: **52 → 95**

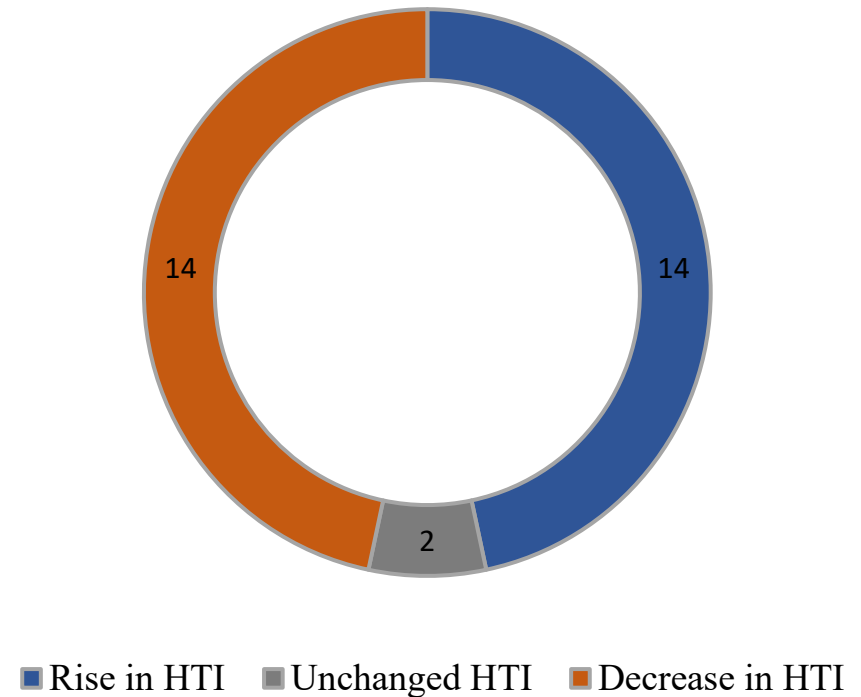


Figure 14 – Triangular HRV index

→ *Did not show any statistically significant changes during hospitalisation*

Trends in Global Variability Indices

SDNN (Standard Deviation of NN intervals)

➤ **Predominantly positive trend:** 18 of the 30 patients (60%) showed an increase in SDNN at discharge

➤ **Notable increases:**

- Patient 12: **54.7 ms → 98.4 ms**
- Patient 21: **29.2 ms → 143.1 ms**
- Patient 28: **33.8 ms → 88.6 ms**

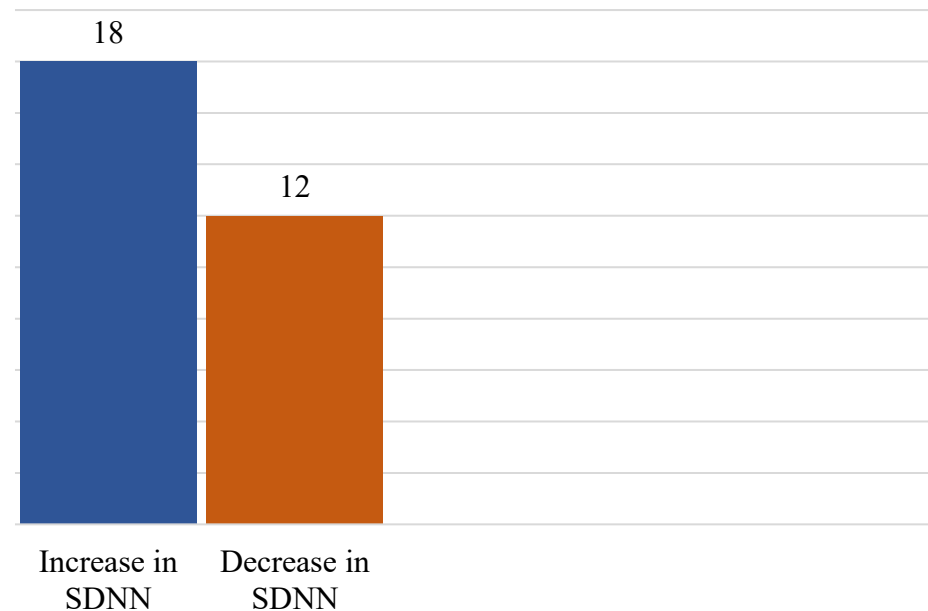
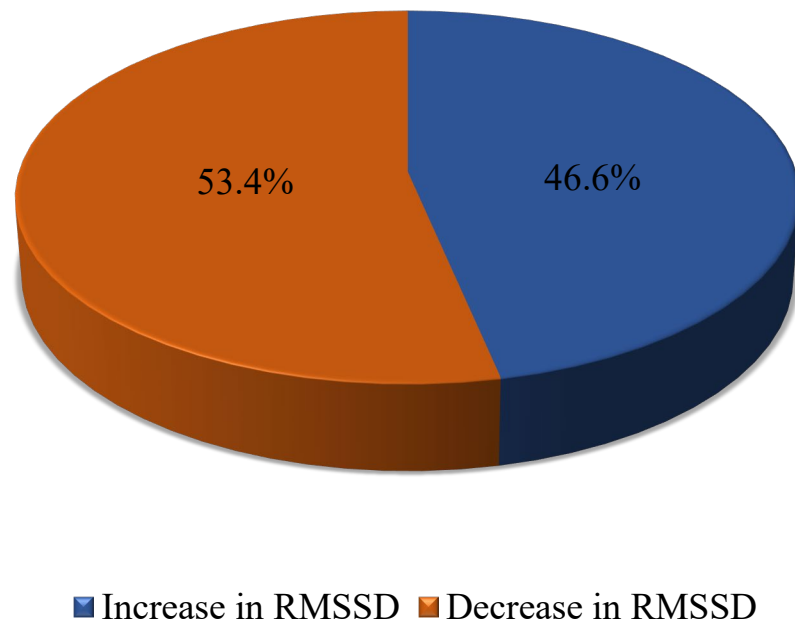


Figure 15 – Standard deviation of NN intervals

→ *Did not show any statistically significant changes during hospitalisation*

Analysis of vagal indicators



RMSSD (ms) – The main indicator of parasympathetic tone:

➤ **Increases:** 14 patients (46.6%) showed an improvement in vagal activity

➤ **Decreases:** 16 (53.4%) patients recorded lower values when discharged compared to admission

➤ **Extreme variations (Positive):**

- Patient 21: 19.6 ms → 159.1 ms
- Patient 28: 18.4 ms → 124.3 ms

Figure 16 – Root mean square of successive differences

→ *Did not show any statistically significant changes during hospitalisation*

Analysis of vagal indicators

NN50 – Rapid variability

- **Increases:** 13 patients (43.3%) showed an increase in this parameter
- **Decreases:** 15 patients (50%) showed lower values compared to admission
- **Stagnation:** 2 patients (6.7%) showed no changes in NN50

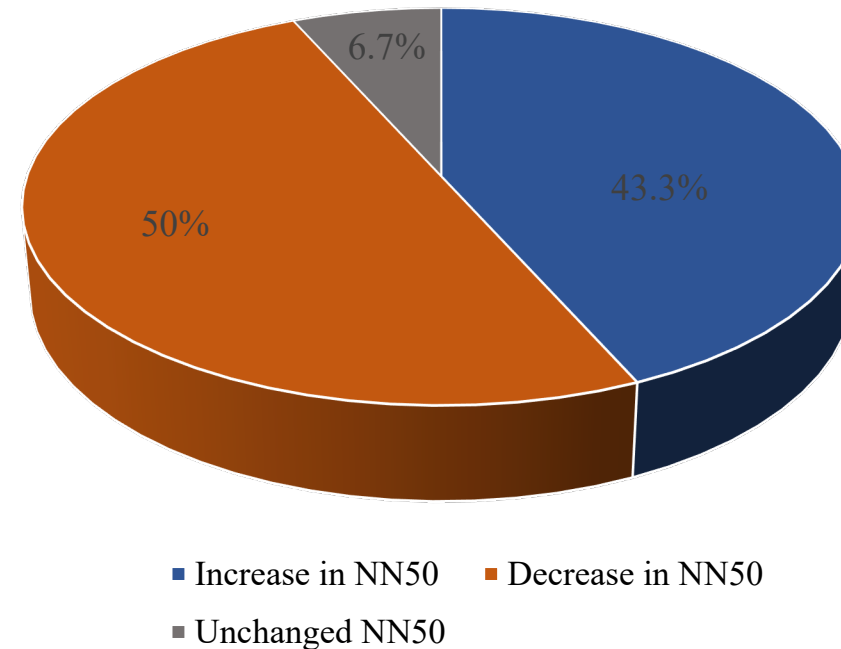


Figure 17 – Rapid variability of the rythm

→ *Did not show any statistically significant changes during hospitalisation*

Analysis of vagal indicators

pNN50 (%) – Percentage of large rhythm variations:

➤ **Increases:** 9 patients showed an increase in pNN50

➤ **Decreases:** 12 patients showed a decrease in this parameter

➤ **Zero values (Unchanged):**

9 patients had a pNN50 of 0% in both measurements

➤ **Notable changes:**

- Patient 12: **22.6% → 45.2%**
- Patient 21: **0% → 60.1%**
- Patient 28: **0% → 52.8%**

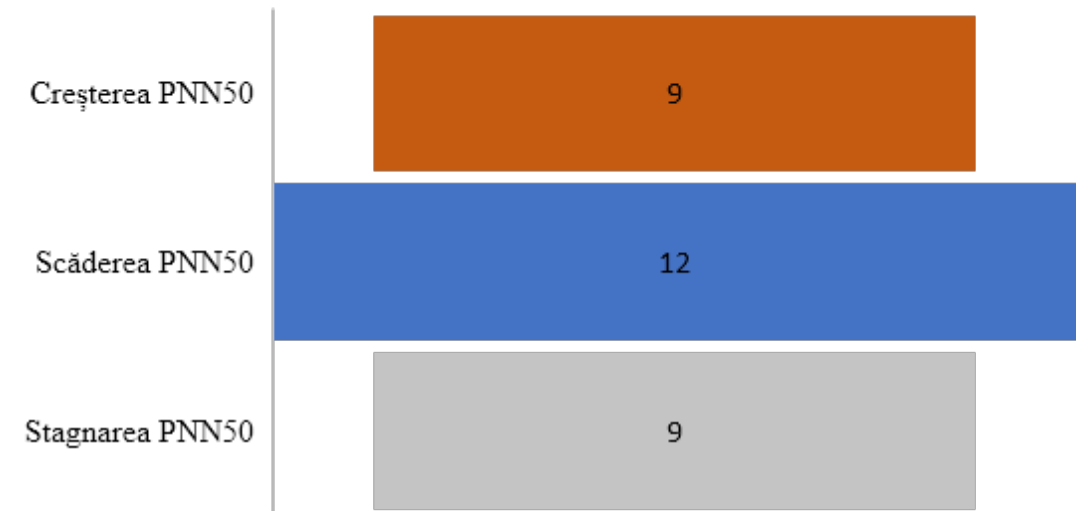


Figure 18 – percentage of large rhythm variations

→ Did not show any statistically significant changes during hospitalisation

Results and Trends: The Impact of Therapy on Autonomic Dynamics

Overall Improvement Trend

- Increased autonomic resilience → The majority of patients (60%) completed the recovery programme with superior adaptive capacity
- Reduction in cardiovascular stress → Over half of the study group (53%) showed a reduction in the Baevsky stress index
 - ✓ 62.5% of all patients who showed a reduction in stress also had associated cardiovascular pathology
- Vagal cardioprotective effect → 43% of patients showed an increase in NN50, indicating a reactivation of parasympathetic (vagal) cardiac protection mechanisms

Dynamics of health profiles

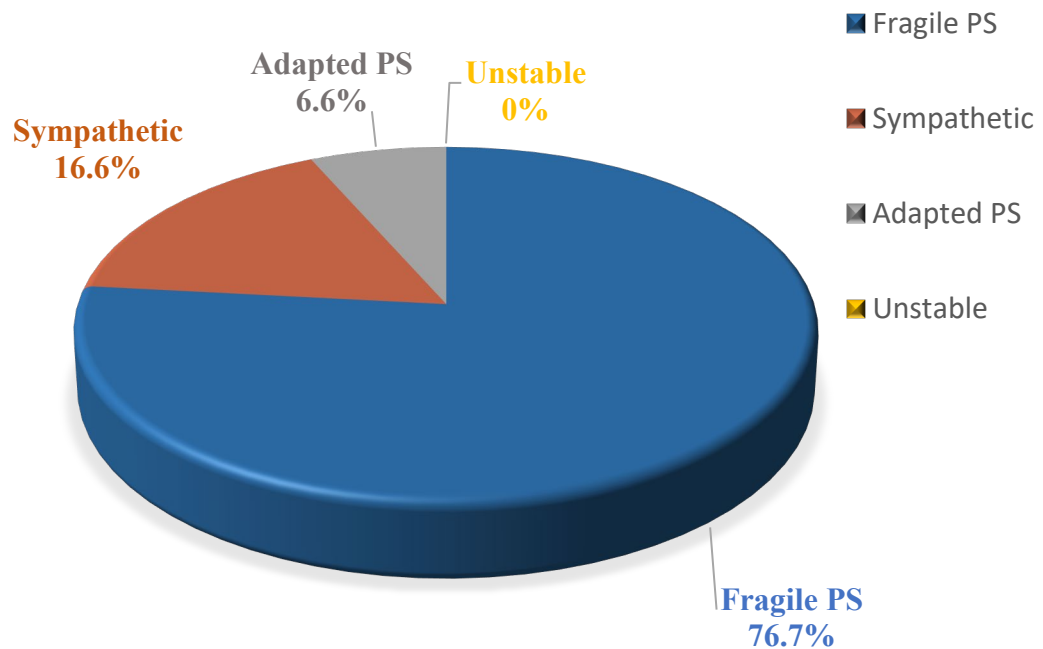
- Absence of the Unstable profile → confirms the safety of the medical recovery protocol

Limitations:

- small sample size of 30 patients
 - no control group
 - diagnostic heterogeneity
 - predominance of female patients
 - the influence of cardiovascular comorbidities and medication on HRV
 - short-term assessment (10 days of treatment), admission–discharge
 - inability to conduct detailed analyses by subgroup
- No universal standardisation yet → active area of research
- The link between HRV and complex balneophysical-kinetic treatment lies in the fact that **recovery interventions modulate the autonomic nervous system, and HRV is the quantifiable expression of this adaptation.** Thus, HRV becomes a **functional biomarker of therapeutic efficacy**, useful both for assessing the response and for tailoring interventions.

Key strengths:

- Use of HRV parameters: ► Objective
► Non-invasive
- Direct clinical applicability in medical recovery
- Modern approach, through the inclusion of IHHT in medical recovery therapy
- Possibility of creating a personalised database



Covasna



Thank You!

