

Exercise Stress Echocardiography of the Right Ventricle and Pulmonary Circulation

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Background

- **Pulmonary artery pressure** is determined by the amount of blood flowing through the pulmonary circulation (**cardiac output**), the intrinsic properties of the vasculature (**resistance, compliance and impedance**), and the left atrial pressure downstream of the pulmonary circuit (**left ventricular diastolic pressure**).

$$\mathbf{mPAP = PVR \times Q + LAP}$$

- Similar to the systemic circulation, **high-output states** and **vascular stiffening** may contribute to increases in systolic pressure in the pulmonary circulation.

Background

On average, each liter per minute of increase Q is accompanied by 1 mmHg increase in mPAP in young adult men and women. Aging to 60-80 years is associated with a more than doubling of the slope of mPAP-Q relationships.

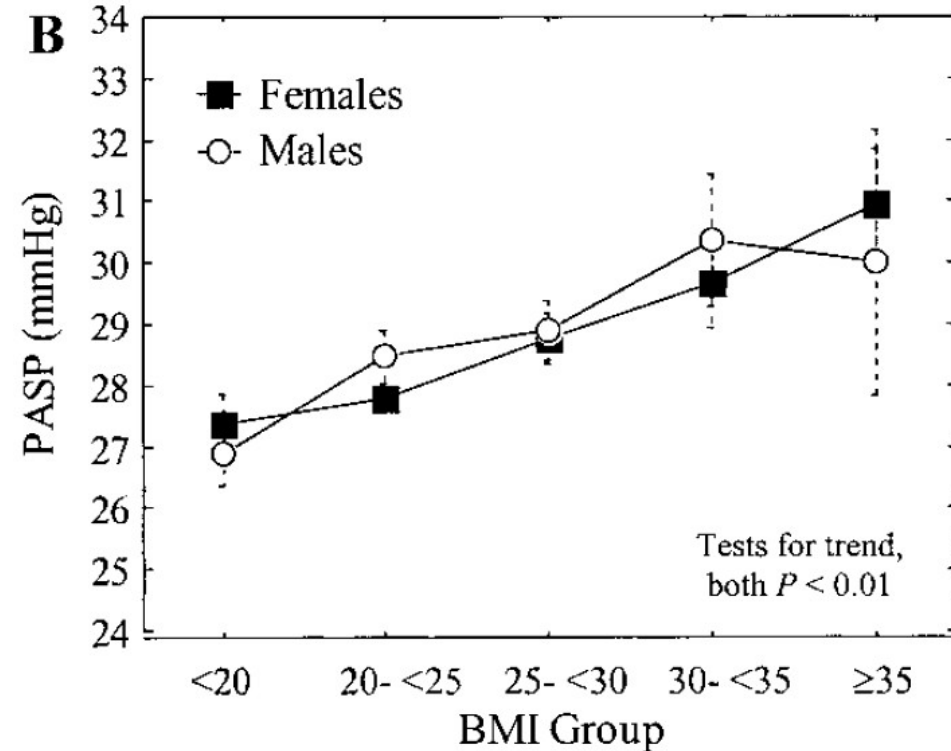
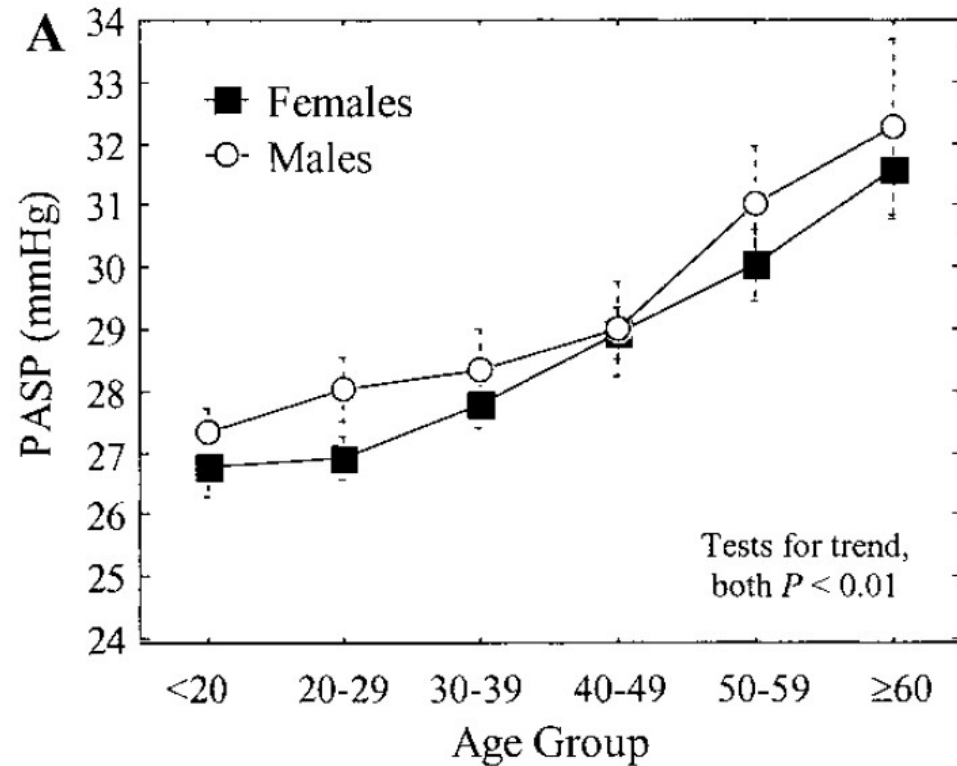
In young adults:

$$\text{mPAP} - Q \approx 1 \text{ mmHg.min.L}^{-1}$$

In old adults:

$$\text{mPAP} - Q \approx 2.5 \text{ mmHg.min.L}^{-1}$$

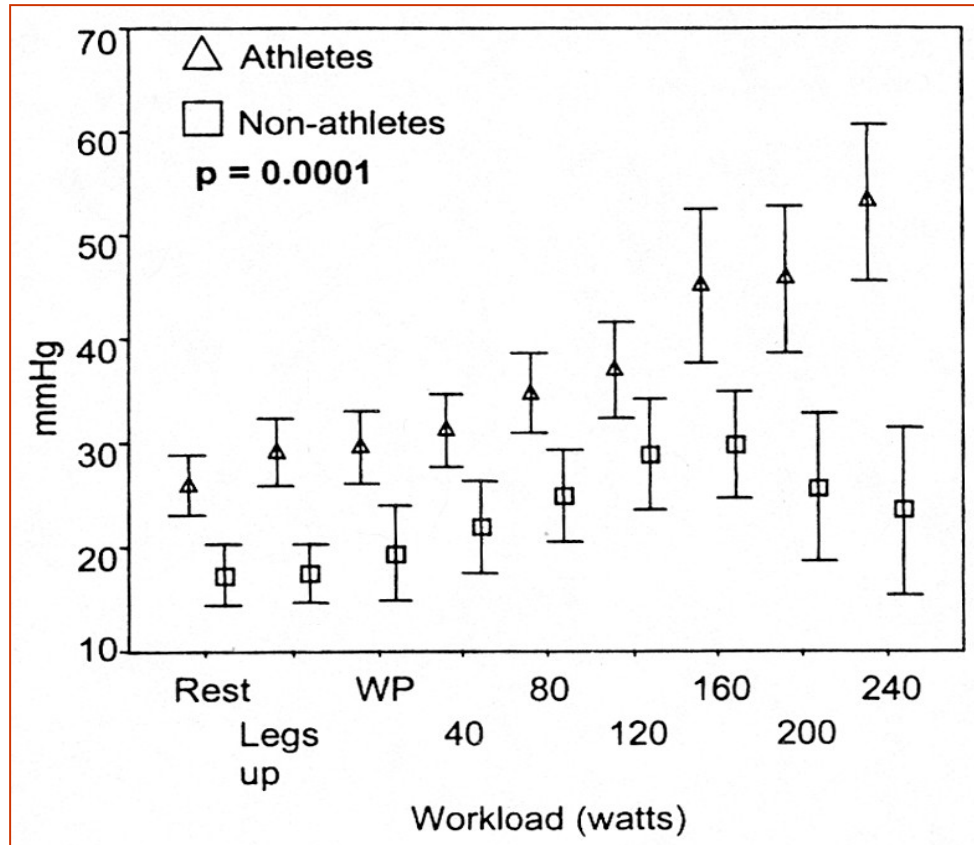
Relation between Pulmonary Artery Systolic Pressure and Age and BMI



The upper limit of PASP is dependent on **Age** and **BMI** and may include 40 mmHg in some older or obese subjects.

Pulmonary Artery Systolic Pressure Response to Exercise

The Physiologic Range



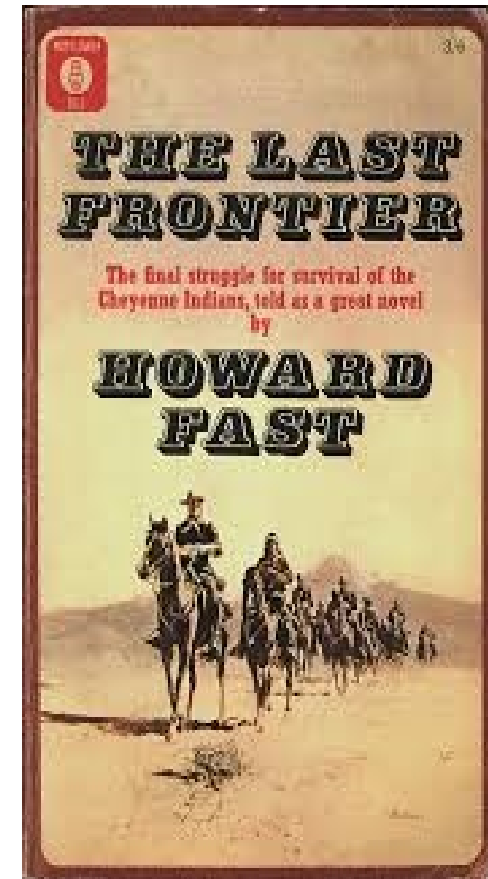
Physiology:

Pulmonary resistance ↓

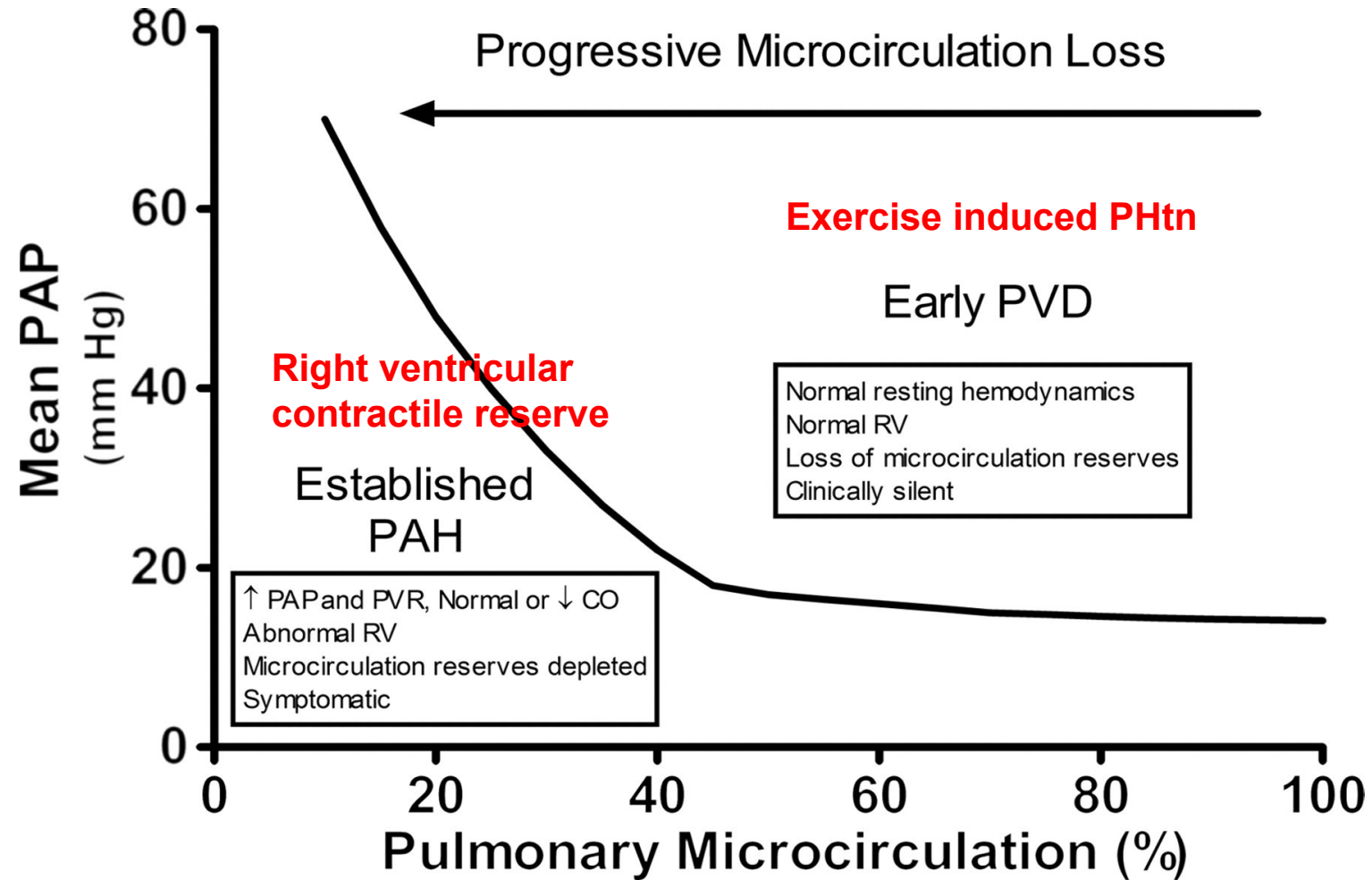
LV filling pressure ↑

Cardiac Output ↑

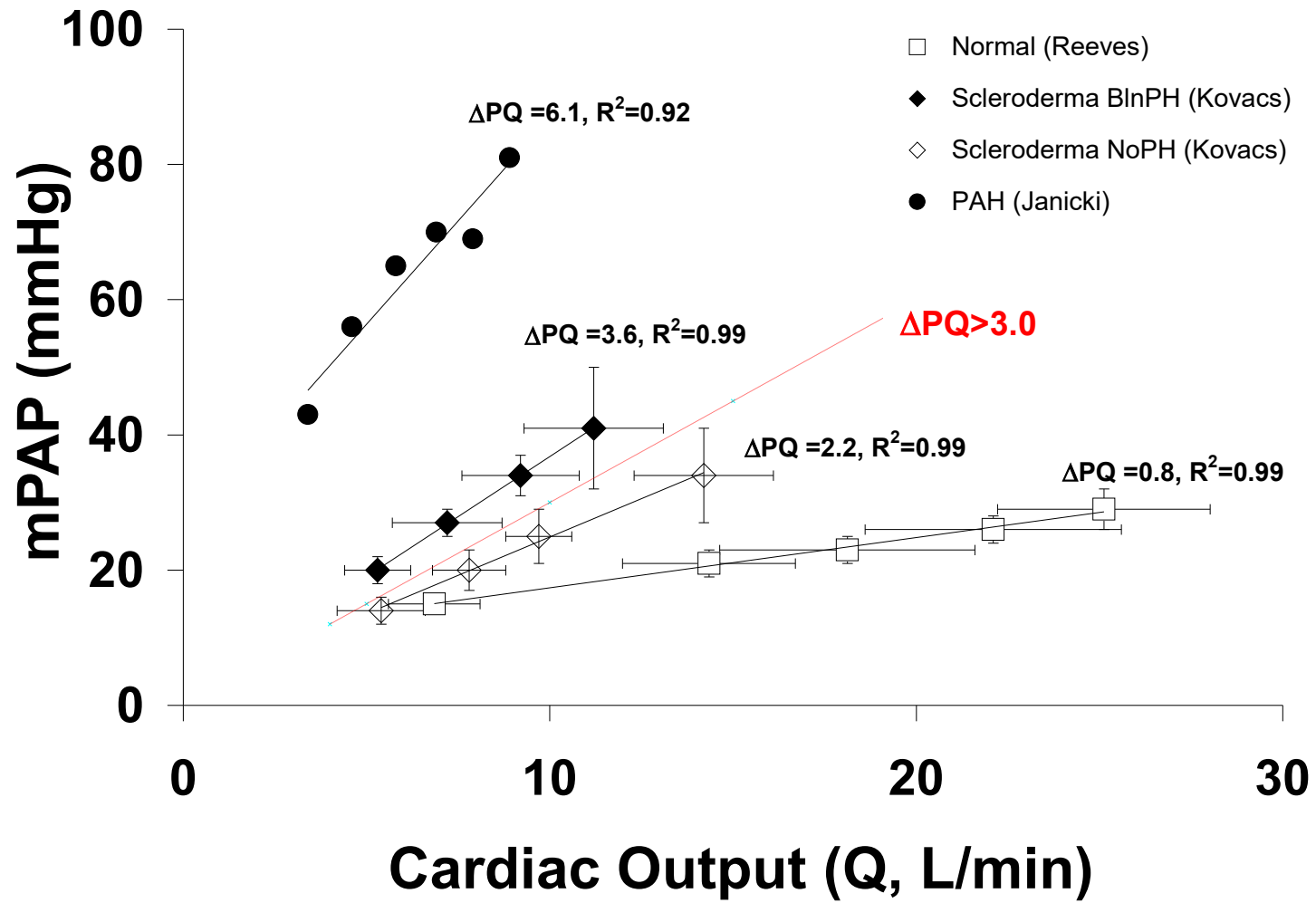
Exercise-induced Pulmonary Hypertension



Relationship between Pulmonary Microcirculation Loss and PAP



The high capacitance of the pulmonary circulation implies that early microcirculation loss is not accompanied by a change in resting PAP.



2022 ESC/ERS Guidelines for the Diagnosis and Treatment of Pulmonary Hypertension

- Exercise PH, defined by an mPAP/CO slope > 3 mmHg/L/min between rest and exercise. The mPAP/CO slope is strongly age dependent and its upper limit of normal ranges from 1.6–3.3 mmHg/L/min in the supine position.
- An mPAP/CO slope > 3 mmHg/L/min is not physiological in subjects aged < 60 years and may rarely be present in healthy subjects aged > 60 years. A pathological increase in pulmonary pressure during exercise is associated with impaired prognosis in patients with exercise dyspnoea and in several cardiovascular conditions.
- Although an increased mPAP/CO slope defines an abnormal haemodynamic response to exercise, it does not allow for differentiation between pre- and post-capillary causes. The PAWP/ CO slope with a threshold > 2 mmHg/L/min may best differentiate between pre- and post-capillary causes of exercise PH.

The Right Heart International Network

RIGHT-NET



THE RIGHT-NET

To create a large prospective and retrospective database of patients with a thorough right heart and pulmonary circulation echocardiographic assessment both at rest and at exercise.

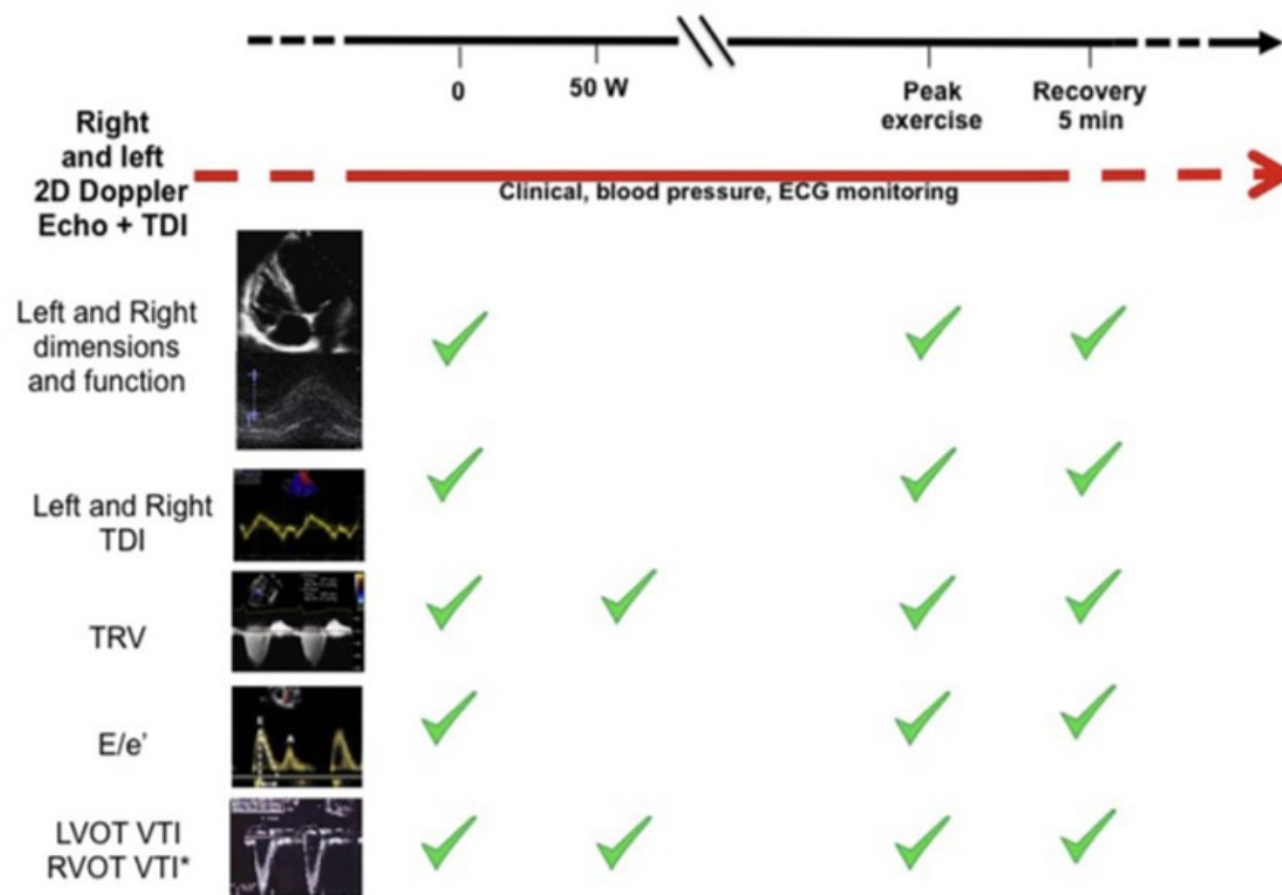
The **database** will be the basis to:

- Set normality ranges
- Elucidate the role of RH and PC in different conditions
- Establish their prognostic meaning

The Right Heart International Network (RIGHT-NET)

Rationale, Objectives, Methodology, and Clinical Implications

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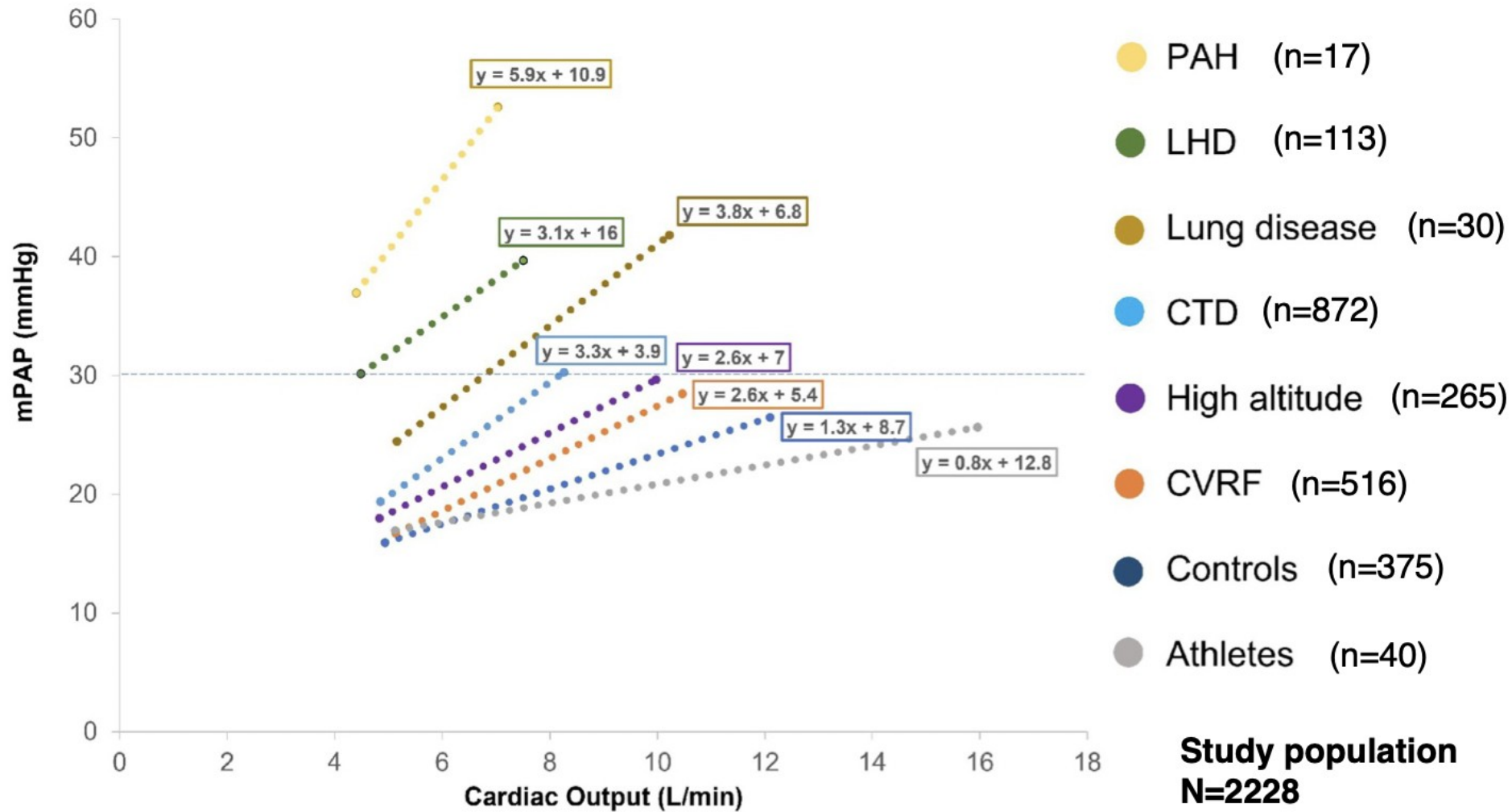
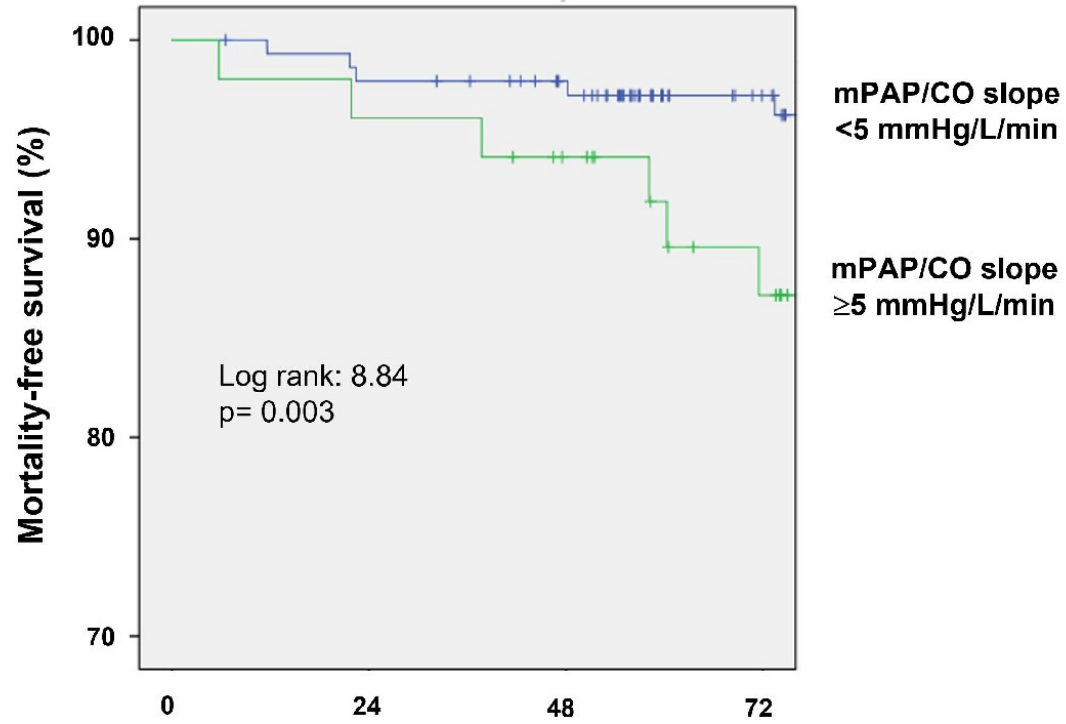


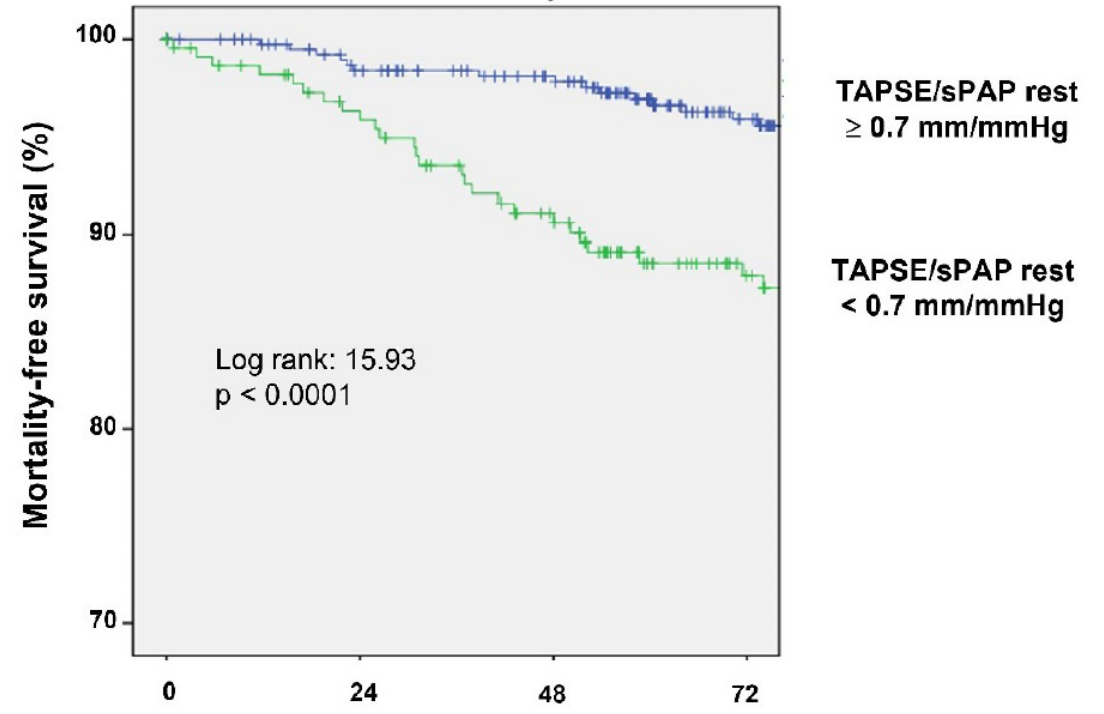
Table 5. Percentage of patients with exercise mPAP/CO>3 mmHg.min/L and mPAP/CO>4 mmHg.min/L in the different Groups.

| Group | mPAP/CO>3 mmHg.min/L | mPAP/CO>4 mmHg.min/L |
|----------------------|--------------------------------|--------------------------------|
| Controls | 18.0% | 5.3% |
| CVRF | 43.0% | 21.9% |
| Athletes | 0% | 0% |
| PAH | 100% | 76.9% |
| CTD | 81.1% | 49.3% |
| LHD | 84.2% | 74.7% |
| Lung disease | 78.3% | 56.5% |
| High altitude | 43.4% | 20.4% |



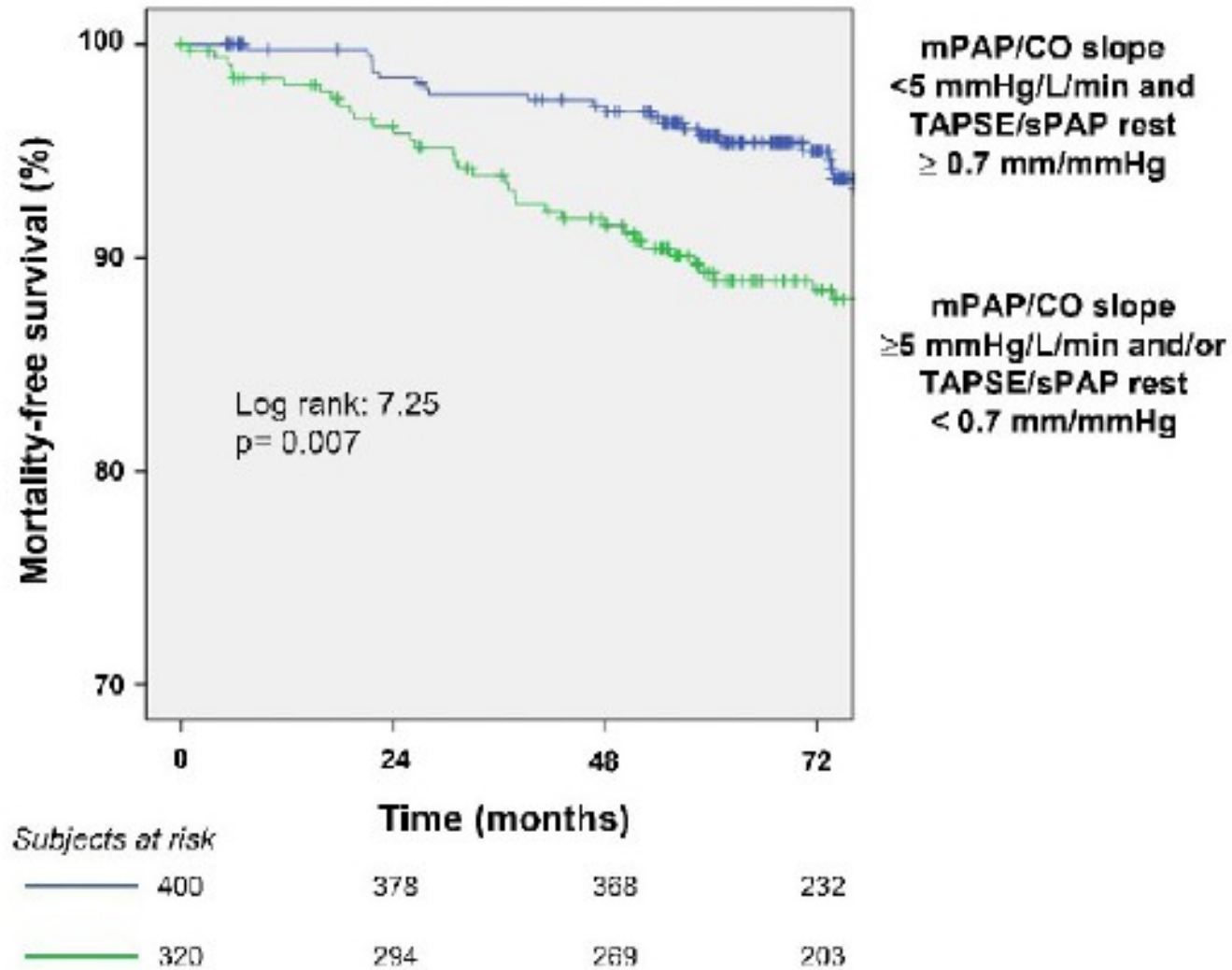
Subjects at risk

| | 0 | 24 | 48 | 72 |
|---|-----|-----|-----|-----|
| — | 147 | 143 | 134 | 101 |
| — | 51 | 49 | 45 | 36 |



Subjects at risk

| | 0 | 24 | 48 | 72 |
|---|-----|-----|-----|-----|
| — | 389 | 363 | 341 | 269 |
| — | 224 | 206 | 184 | 140 |



Take-home message

Exercise echocardiography can effectively and non-invasively characterize different dynamic behaviors among healthy subjects, athletes, and patients with various pathological conditions, and help to the diagnosis of latent or overt PH with or without altered RV function adaptation to increased loading conditions.

Further studies are needed to further clarify the prognostic impact of exercise-induced PH and the effects of early interventions.

“Principiis obsta; sero medicina paratur cum mala per longas convaluere moras”.
Remedia Amoris 91-92.



“Stop it at the beginning; a cure is attempted too late when, through long delay, the illness has gained strength”