

AI-03118 LVEF vs Heartrate

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What is LVEF? Deep dive . When and how was it discovered? Can LVEF be estimated via resting heart rate, max heart rate during exercise?

Let's deep dive into LVEF (Left Ventricular Ejection Fraction) — its physiology, measurement, history, and whether it can be estimated indirectly through heart rate or exercise data.

1. Definition: What is LVEF?

Left Ventricular Ejection Fraction (LVEF) is the percentage of blood ejected from the left ventricle with each heartbeat relative to the total volume of blood it contains at the end of diastole.

$$\text{LVEF} = \frac{\text{Stroke Volume}}{\text{End-Diastolic Volume}} \times 100$$

- Normal: 55–70%
- Mildly reduced: 41–54%
- Moderately reduced: 30–40%
- Severely reduced: <30%

It's a global index of left ventricular systolic function, one of the most critical parameters in cardiology for diagnosing and monitoring heart failure, cardiomyopathy, valvular disease, and post-myocardial infarction recovery.

2. Physiological Deep Dive

A. Cardiac Cycle Components

- End-Diastolic Volume (EDV): The volume of blood in the LV just before contraction (~120 mL in adults).
- End-Systolic Volume (ESV): The volume remaining after contraction (~50 mL).
- Stroke Volume (SV): Blood ejected per beat = EDV – ESV (~70 mL).

LVEF reflects contractility, afterload, and preload, but it is not purely a contractility index — it’s a composite influenced by loading conditions.

B. Determinants of LVEF

1. Myocardial contractility – intrinsic ability of cardiac muscle to shorten.
2. Preload – venous return affecting EDV.
3. Afterload – resistance against which the ventricle ejects blood.
4. Heart rate – affects filling time and contractile efficiency.
5. Myocardial ischemia or scar – regional wall motion abnormalities can reduce global LVEF.

3. History: When and How Was LVEF Discovered

| Era | Discovery Milestone | Key People/Methods |
|-------------|---|--|
| 1950s–1960s | Concept of ventricular volumes and ejection fraction emerged. | Dr. Eugene Braunwald and others studying hemodynamics. |
| 1960s | First invasive measurements using ventriculography with contrast via cardiac catheterization. | Introduced quantitative imaging of cardiac function. |
| 1970s | Echocardiography began to estimate LV dimensions noninvasively. | Feigenbaum and colleagues pioneered M-mode and 2D echo. |
| 1980s–1990s | Radionuclide ventriculography and MRI allowed precise, reproducible LVEF measurement. | Advanced imaging established it as gold-standard metric. |

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| 2000s–Present | 3D echocardiography and strain imaging improved accuracy and sensitivity. | Noninvasive and repeatable for monitoring disease progression. |
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4. Measurement Techniques

| Method | Description | Pros | Cons |
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| Echocardiography (2D/3D) | Uses ultrasound to calculate LV volumes (Simpson's biplane method). | Widely available, safe, repeatable. | Operator-dependent, assumes geometric shape. |
| Cardiac MRI | Gold standard for volume and EF measurement. | Highly accurate, 3D view of LV geometry. | Expensive, less available. |
| Nuclear Imaging (MUGA) | Traces labeled red blood cells to compute EF. | Very reproducible. | Radiation exposure. |
| Cardiac Catheterization (Angiography) | Contrast injected to visualize LV contraction. | Historical gold standard. | Invasive, radiation risk. |

5. Can LVEF Be Estimated from Heart Rate or Exercise Data?

Short Answer:



No, not directly or reliably.

LVEF cannot be accurately estimated from resting heart rate (RHR), maximum heart rate (HRmax), or even heart rate recovery because these reflect chronotropic response (rate function), not mechanical pumping efficiency (volume function).

Explanation

| Parameter | What It Reflects | Correlation with LVEF | Why It's Not Reliable |
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| Resting Heart Rate | Autonomic tone, fitness, stress, thyroid, etc. | Weak, indirect. | A low RHR doesn't mean strong LV contraction (e.g., beta-blocker use). |
| Max Heart Rate During Exercise | Age-related cardiac pacing limit. | None. | EF depends on stroke volume, not rate capacity. |
| Heart Rate Recovery | Autonomic reactivation post-exercise. | Weak to moderate in population studies. | Reflects vagal tone, not mechanical ejection. |
| Cardiac Output (CO) | $HR \times SV$. | Related but not interchangeable. | You'd still need SV (which requires imaging or impedance cardiography). |

Even athletes with bradycardia can have normal or high EF, while heart failure patients with tachycardia can have poor EF — showing no fixed HR–EF link.

Indirect Clues (Rough Physiologic Correlates)

While HR can't predict EF, some non-invasive surrogates can hint at it:

- Pulse pressure (SBP–DBP) roughly tracks stroke volume.
- Oxygen pulse (VO_2/HR) during cardiopulmonary testing correlates modestly with stroke volume.
- Echocardiographic fractional shortening (FS) or strain imaging are better proxies.

Still, all require imaging or physiological measurement beyond HR.

6. Summary Synthesis

| Concept | Essence |
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| Definition | LVEF = % of blood ejected from LV per beat; a measure of systolic function. |

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| Discovery | Originated from invasive ventriculography in the 1950s–60s; now primarily via echocardiography and MRI. |
| Significance | Central in diagnosing and classifying heart failure (HFrEF, HFmrEF, HFpEF). |
| Estimation from HR | Not possible; HR reflects electrical rate, EF reflects mechanical performance. |
| Reliable Measurement | Requires imaging (echo, MRI, nuclear). |

7. Actionable Insight

If one wants to track cardiac performance without imaging, the next best periodic metrics are:

- VO_2 max or oxygen pulse during cardiopulmonary exercise testing.
- Resting BP and pulse pressure trends.
- Heart rate variability (HRV) for autonomic balance.
- Serial echocardiography if clinically indicated.

Would you like me to include how LVEF changes with endurance training and how athletes' hearts differ from cardiomyopathy (physiologic vs pathologic hypertrophy)? It's a fascinating and clinically important extension.