

**제1회
스포츠 심장 연구회
발족 기념 심포지움**

Imaging the Athlete's Heart – From Basics to Advanced

전남의대 조재영



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2023년 2월 18일(토), 대구 메리어트 호텔 이스트홀



Imaging the Athlete's Heart

– From Basics to Advanced –

전남대학교병원 순환기내과

조재영

CNU Hospital
Cardiovascular Medicine



What is athlete's heart?

Hemodynamic overload due to long-term training typically involves both left and right ventricles, inducing changes in cardiac structure globally described as “**athlete's heart**”



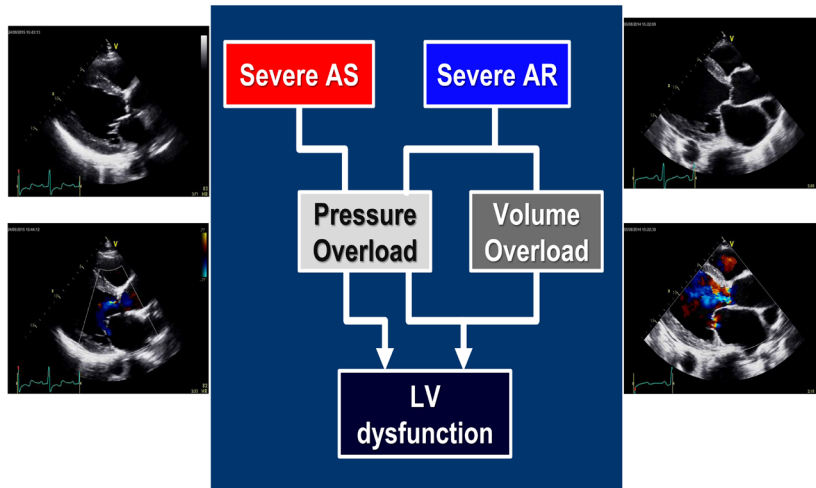
Pluim BM, et al. *Circulation* 2000;101:336-44

Pelliccia A, Maron BJ, et al. *New Engl J Med* 1991;324:295-301

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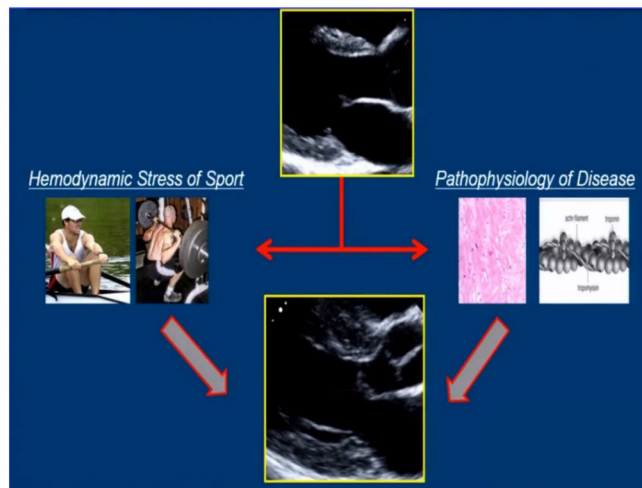
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Comparison with pathologic overload



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Cardiac remodeling: Healthy state vs. Disease

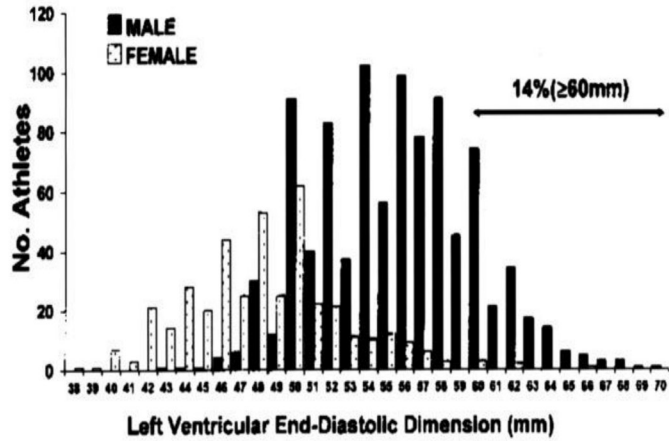


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Aaron Baggish, ASE 2015

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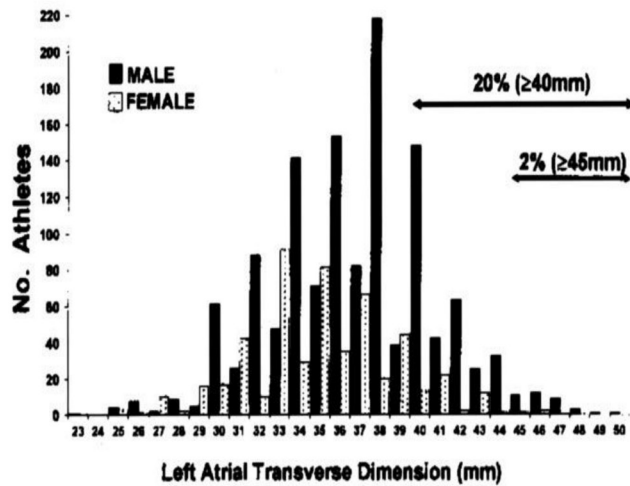
LV chamber dilation



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Pelliccia A, Maron BJ, et al. N Engl J Med. 1991;324:295-301

Increased LA diameter

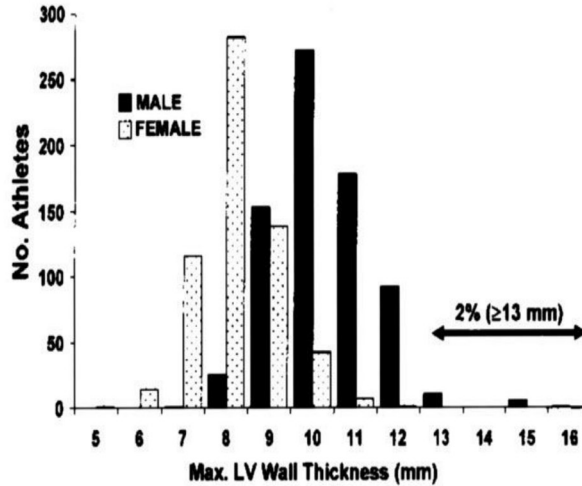


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Pelliccia A, Maron BJ, et al. N Engl J Med. 1991;324:295-301

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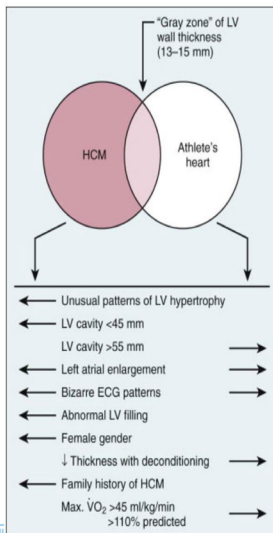
Increased LV wall thickness



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Pelliccia A, Maron BJ, et al. N Engl J Med. 1991;324:295-301

Athlete's heart vs. HCM



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Table 1 Distinguishing athlete's heart from HCM

| Data feature | Athlete's heart | HCM | Value |
|------------------------------|-----------------|----------|-------|
| Increased wall thickness | Yes | Yes | No |
| Atrial remodeling | Yes | Yes | No |
| Systolic function | Normal | Normal | No |
| Mechanical function (strain) | Normal | Abnormal | Yes |
| Diastolic physiology | Normal | Abnormal | Yes |

Data from Paterick TE, Jan MF, Paterick ZR, Umland MM, Kramer C, Lake P, et al. Cardiac evaluation of collegiate student athletes: a medical and legal perspective. Am J Med 2012;125:742-752.

Am J Med 2012;125:742-52
 Braunwald Heart Disease 9th

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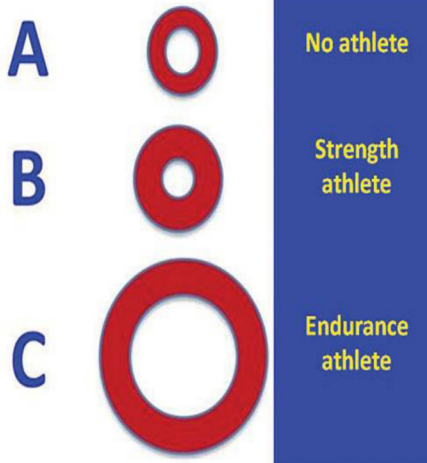
Exercise-induced cardiac remodeling (EICR)

EICR enhances the cardiovascular system's ability to meet

the demands of exercising skeletal muscle

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The 'Morganroth hypothesis'



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Eur Heart J Cardiovasc Img 2015;16:353

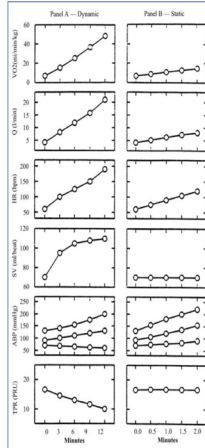
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EICR according to type of training

Endurance training



- Sustained CO increase
 - 4-5 times rest
 - HR increase (+++)
 - SV increase (+)
 - Vasodilation



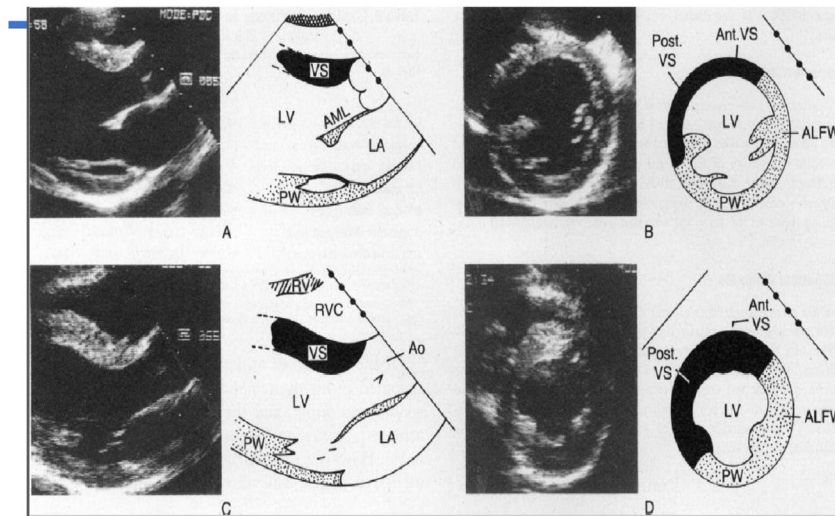
Strength training



- Repetitive SBP elevation
 - Systolic BP >200 mmHg
 - Skeletal m. contraction
 - Increased LV afterload

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Mitchell et al. J Am Coll Cardiol 2005;45:1364-7

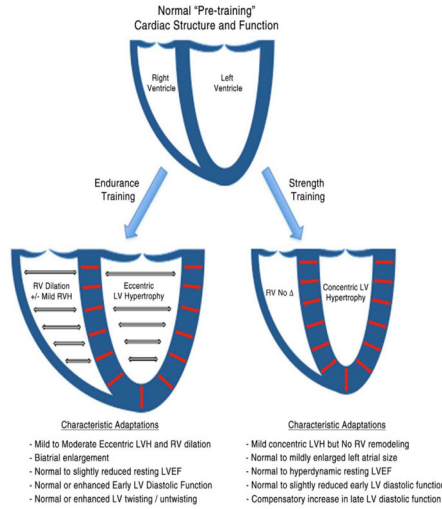


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Pelliccia A, Maron BJ, et al. N Engl J Med. 1991;324:295-301

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Sport-specific nature of EICR

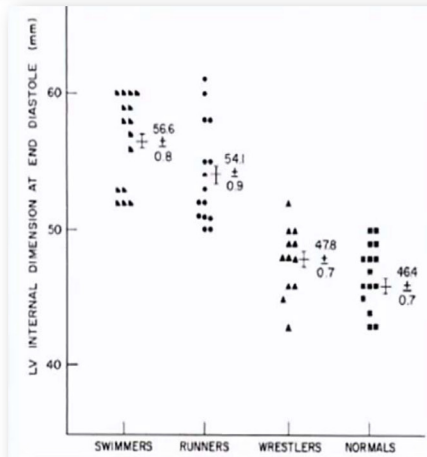


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Weiner RB, Baggish AL. Prog Cardiovasc Dis 2012;54:380

Comparative Left Ventricular Dimensions in Trained Athletes

JOEL MORGANROTH, M.D., BARRY J. MARON, M.D., WALTER L. HENRY, M.D.,
and STEPHEN E. EPSTEIN, M.D., Bethesda, Maryland



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Annals of Int Med 1975;82:521

Memo

Deformation imaging in athletes

• LV at rest:

- **Increased** function: IRichard V, Am J Cardiol 2007
- **Similar** as normal persons: Nottin S, J Physiol 2008 & Fujimoto N, Circulation 2010

• LV during exercise:

- **Heterogenous** results: La Gerche A, Heart 2012

• RV at rest

- **Decreased** function when dilated RV: Teske AJ, Eur Heart J 2009

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Deformation Imaging in Young Athletes

| | Athletes (n=162) | Normal control (n=42) | P value |
|--|---------------------|--------------------------|---------|
| Age (years) | 22±2 | 25±3 | <0.001 |
| Female gender (%) | 82 (51%) | 23 (55%) | 0.730 |
| Body surface area (m ²) | 1.8±0.2 | 1.7±0.2 | <0.001 |
| Systolic blood pressure (mmHg) | 118±13 | 116±12 | 0.383 |
| Diastolic blood pressure (mmHg) | 65±12 | 70±10 | 0.013 |
| Heart rate (/min) | 65±12 | 71±11 | <0.001 |
| LV end-diastolic volume (mL) | 124±34 | 109±25 | 0.015 |
| LV end-systolic volume (mL) | 45±16 | 42±13 | 0.244 |
| LV ejection fraction (%) | 64±6 | 62±5 | 0.047 |
| LV mass (gm) | 135±46 | 111±29 | <0.001 |
| LV longitudinal strain, apical 4 chamber (%) | -19.9±2.7 | -20.0±2.5 | 0.741 |
| apical 3 chamber (%) | -19.0±2.8 | -20.5±3.2 | 0.004 |
| apical 2 chamber (%) | -20.5±2.7 | -21.3±2.5 | 0.074 |
| global value (%) | -19.8±2.4 | -20.7±2.4 | 0.030 |

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Park JH, Kim KH, JY Cho, et al. 2016 ESC abstract

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Athletes vs. Sedentary controls

- Trained athletes have cardiac remodeling not only in the increased size and volume of cardiac chambers, but also in the increase of LV thickness.
- Also RV shows increased dimension, however, the thickness remains unchanged unlike LV.

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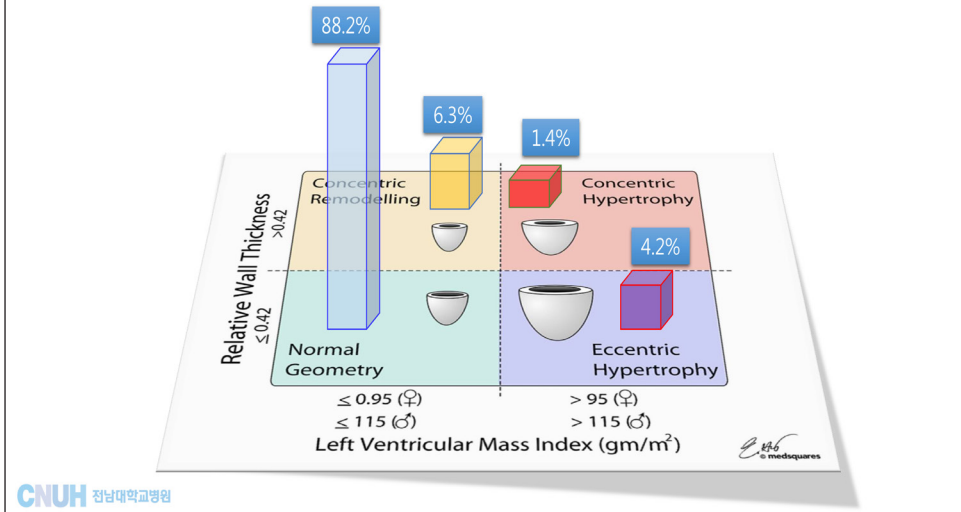
Athletes vs. Sedentary controls

- Despite of these cardiac remodeling, diastolic function was normal in both groups and even enhanced (hypernormal) in the athlete group.
- Considering the normal cardiac function of this population, it is suggested that cardiac remodeling in athletes would be a physiologic change.

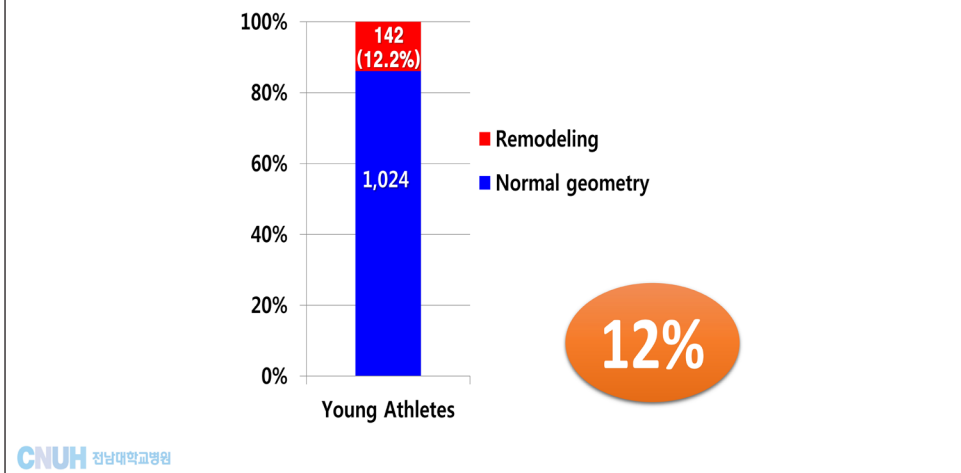
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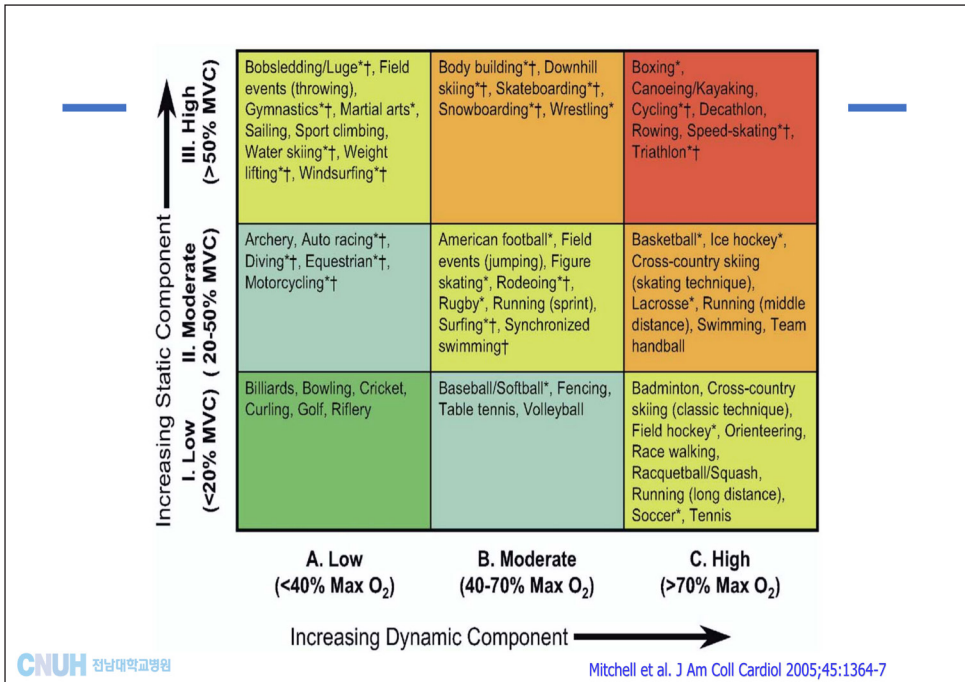
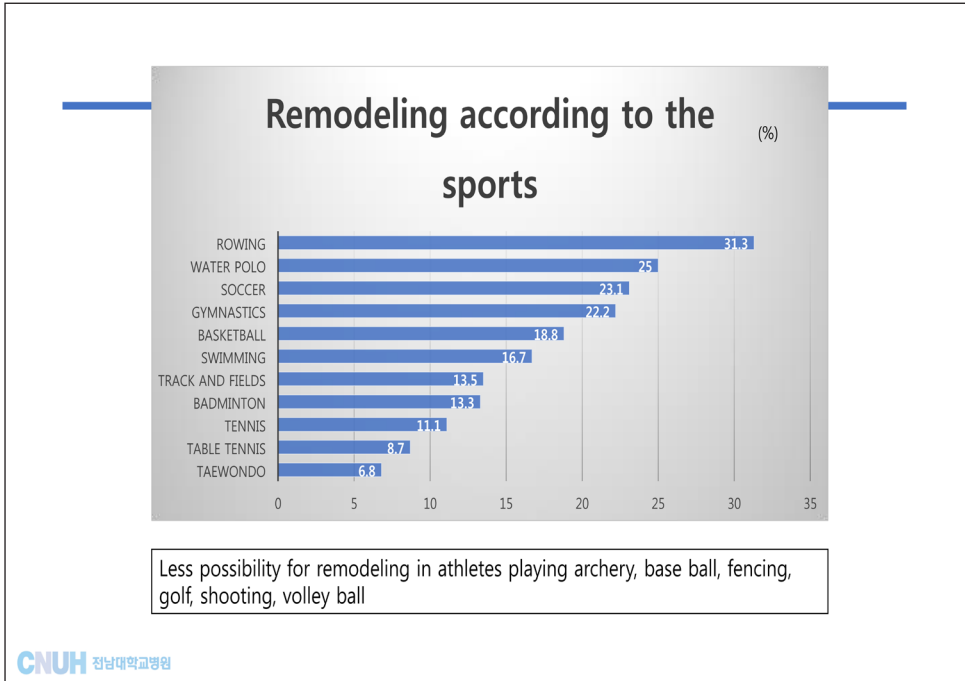
Remodeling Patterns in Young Athletes



Remodeling proportion



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Memo

Take Home Message



- **운동선수심장이란?** 강도높은 운동에 따른 혈액학적인 부하에 심장이 적응하기 위해 구조적 변화가 일어나는 것
- **병적인 상태와의 구별?**
 - 심실 및 심방의 크기에 한계
 - 심실이 커도 수축기능은 정상적이다
 - 심실벽이 두꺼워도 이완기능은 정상적이다
 - 운동을 중단하면 원래대로 돌아온다

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Take Home Message



- **심실 재형성의 두가지 기전**
 - Eccentric vs. concentric remodelling
 - Endurance training vs. Strength training 의 결과
 - 하지만 각각의 운동은 mixed training 이 대부분이다
- **새로운 기법으로 지속적인 연구가 필요**
 - Strain method 등
 - 운동선수 심장 **돌연사 예방**에 기여

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