

PHYSIOLOGICAL UPPER LIMITS OF CARDIAC DIMENSIONS IN ADOLESCENT ATHLETES

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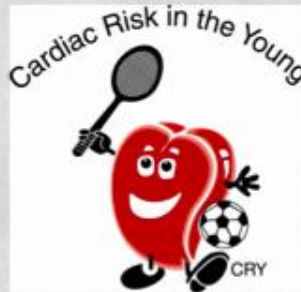
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DISCLOSURES

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charitable organisation

Cardiac Risk in the Young



- What constitutes CV adaptation to exercise
- Factors influencing cardiac adaptation
- Left ventricular wall thickness
- Left ventricular cavity size
- Left atrial diameter, Aortic root size
- Right ventricular dimensions
- Effect of ethnicity
- Differentiating physiology from pathology

CARDIOVASCULAR ADAPTATION TO EXERCISE

↑ Cardiac, Respiratory & Muscular endurance

+

↑ Circulating blood volume

+

Metabolic adaptations



↑ Availability & more effective utilisation of energy

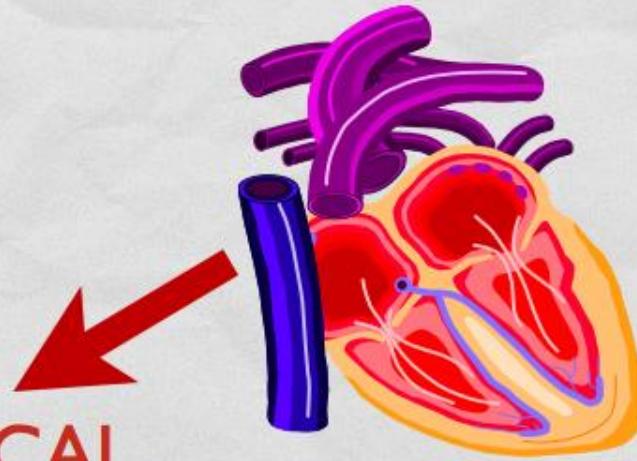


↑ $\text{Max-VO}_2 = \text{CO} \times (\text{A-V})\text{O}_2$

ADULT “ATHLETE’S HEART”



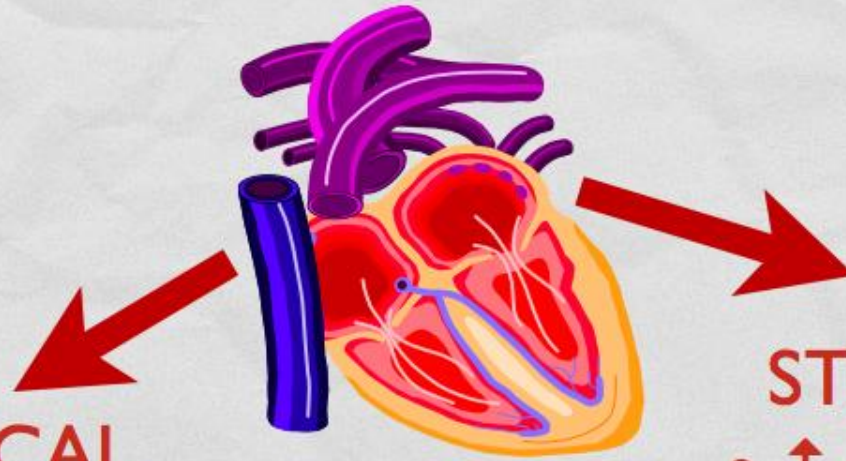
ADULT “ATHLETE’S HEART”



ELECTRICAL

- ↑ Parasympathetic tone

ADULT “ATHLETE’S HEART”



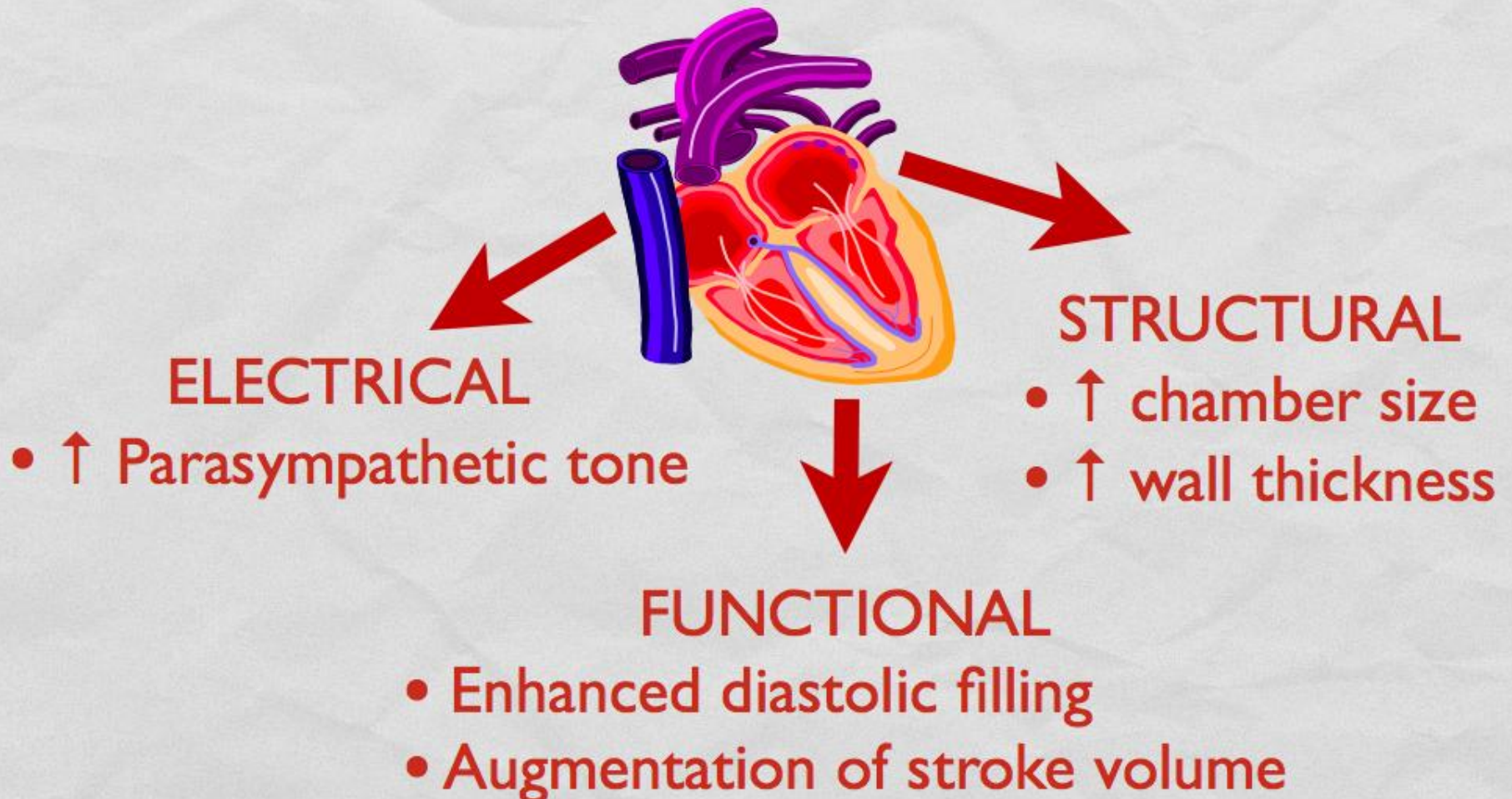
ELECTRICAL

- ↑ Parasympathetic tone

STRUCTURAL

- ↑ chamber size
- ↑ wall thickness

ADULT “ATHLETE’S HEART”



META-ANALYSIS OF “ATHLETE’S HEART”

59 STUDIES, 1451 ATHLETES, 1975-1998

	Athletes	Controls	p-value
LVIDd (mm)	56.2	49.6	<0.001
LVPWd (mm)	11.0	8.8	<0.001
IVSd (mm)	11.3	8.9	<0.001
LVM (g)	288	174	<0.001

Pluim BM et al. Circulation 1999;100:336-344

FACTORS INFLUENCING CARDIAC ADAPTATION TO EXERCISE

Gender

Size

Genetic

Sporting
Discipline

Athlete's
Heart

Cardiac
Pathology

Ethnicity



FACTORS INFLUENCING CARDIAC ADAPTATION TO EXERCISE

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AGE

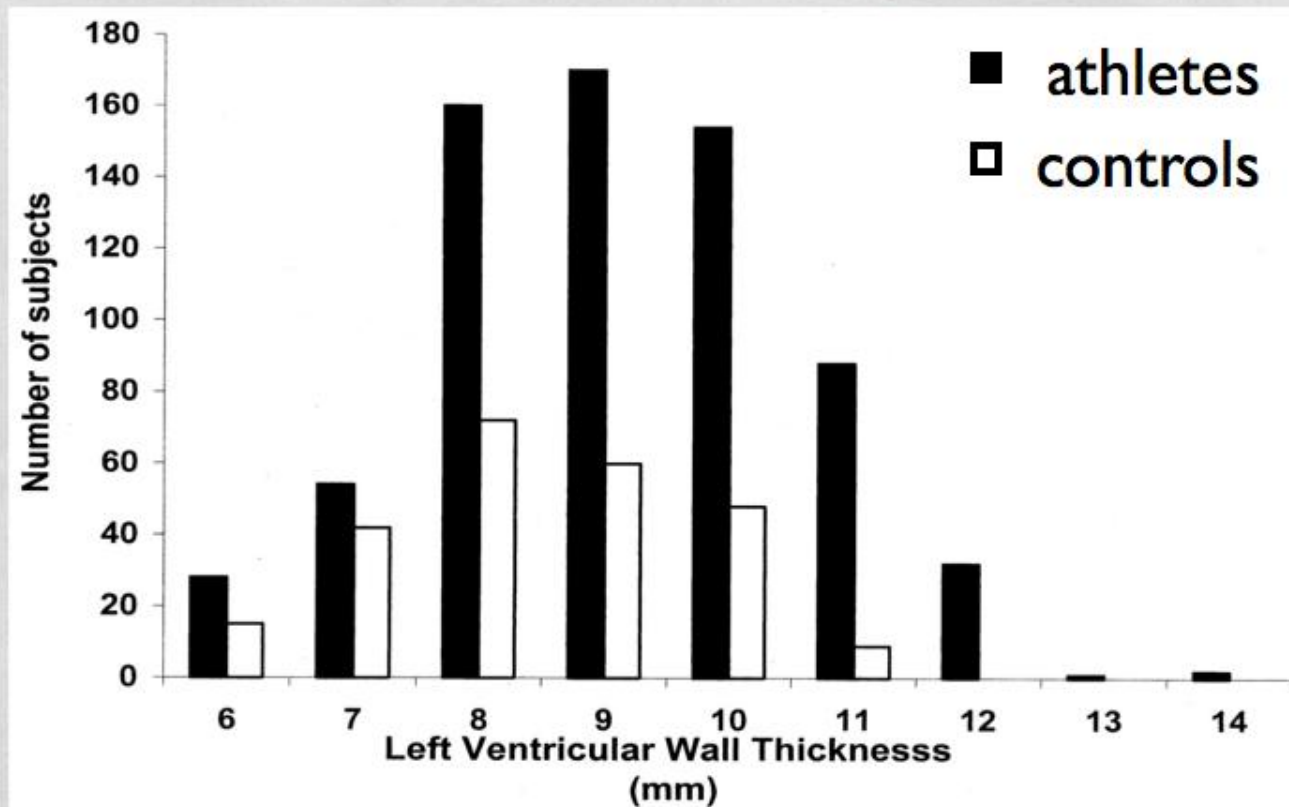


THE EFFECT OF AGE

- Limited adaptation in pre-pubertal athletes
- Adults exhibit significant adaptation to exercise
- ? Degree of cardiac adaptation in adolescent athletes

LEFT VENTRICULAR HYPERTROPHY IN ADOLESCENT ATHLETES

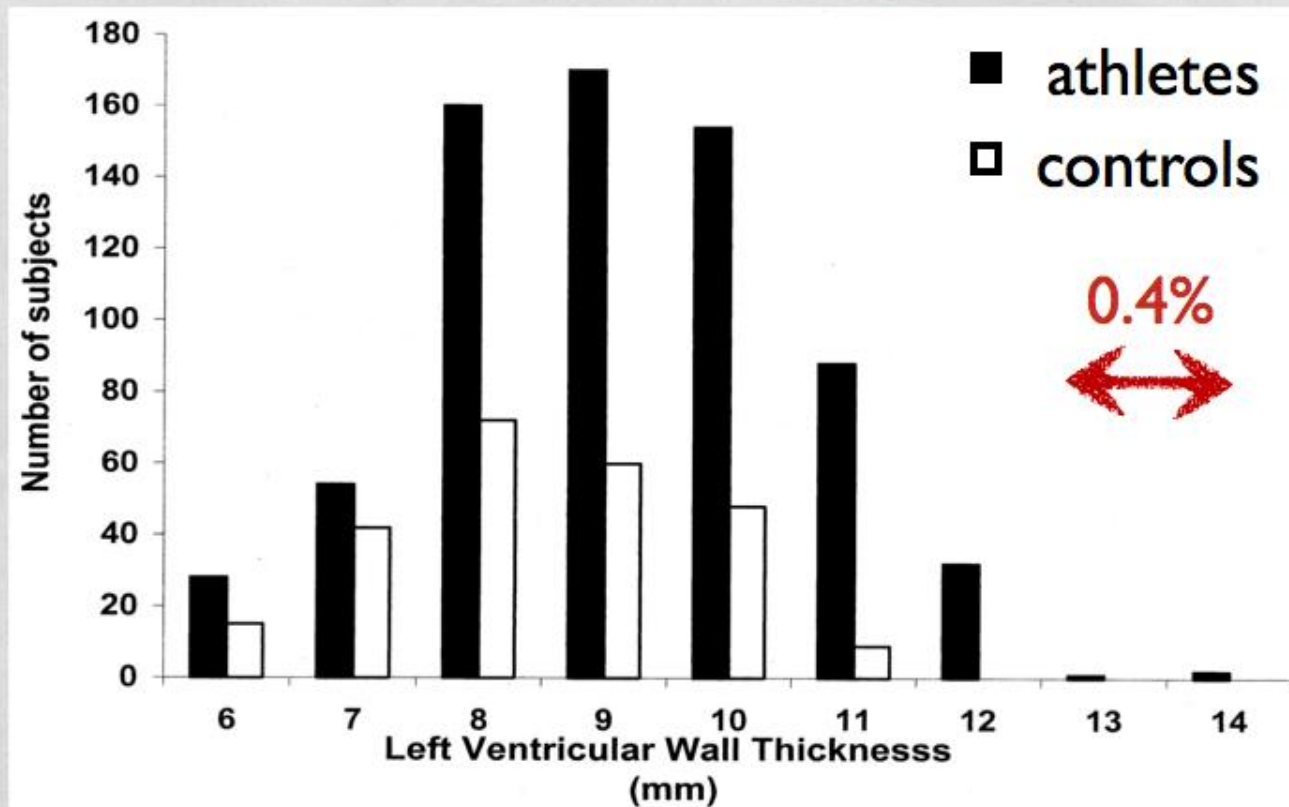
- 720 elite athletes vs. 250 sedentary controls



Sharma S et al. JACC 2002;40:1431-1436

LEFT VENTRICULAR HYPERTROPHY IN ADOLESCENT ATHLETES

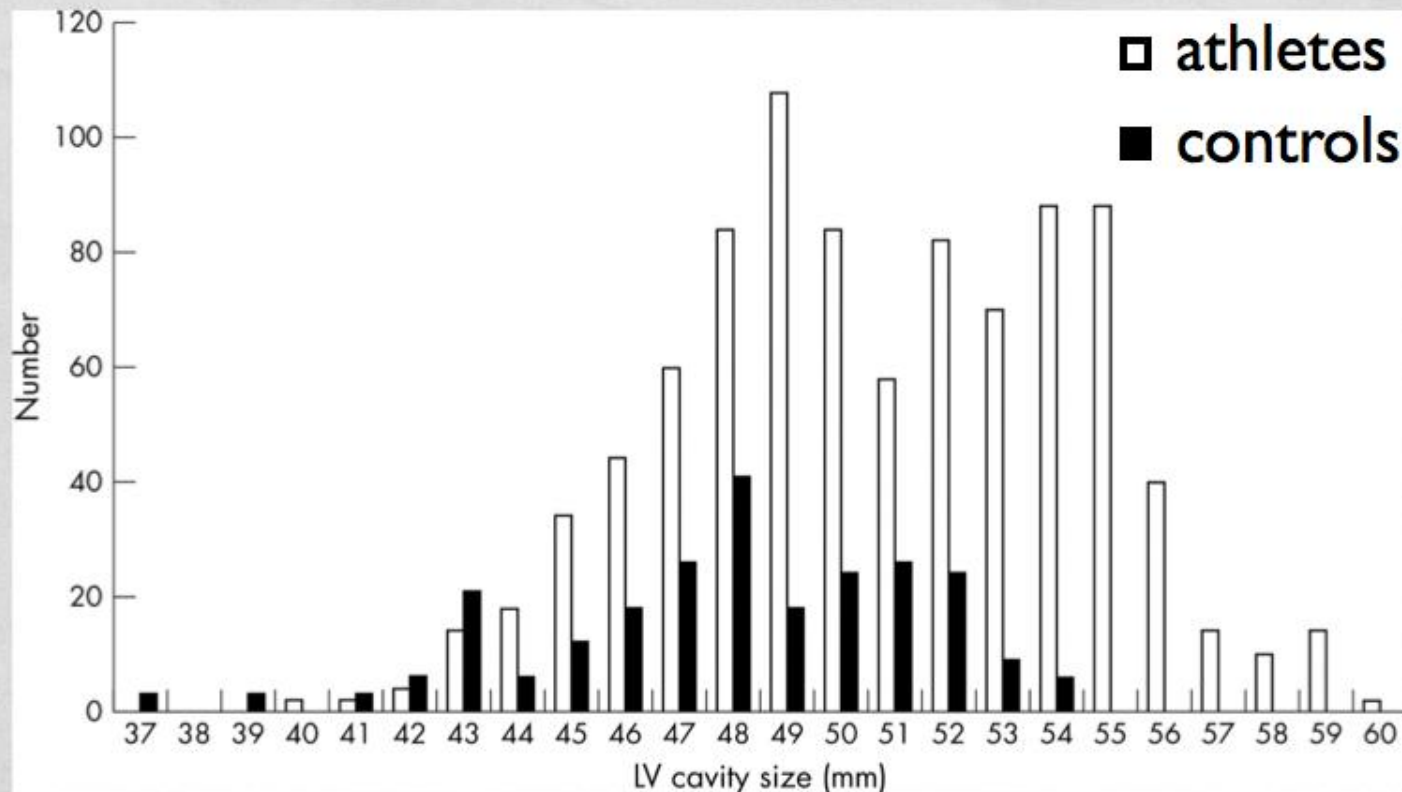
- 720 elite athletes vs. 250 sedentary controls



- No female athlete exhibited $LVWTd > 11\text{mm}$
- LVH was associated with:
 - $\uparrow LVEDd$
 - Normal diastolic indices
- In contrast to adult athletes, adolescents
 - $LVWTd \leq 14\text{mm}$ (16mm in adults)
 - Only 0.4% exhibiting a $LVWTd > 12\text{mm}$ (4% in adults)

LEFT VENTRICULAR CAVITY SIZE IN ADOLESCENT ATHLETES

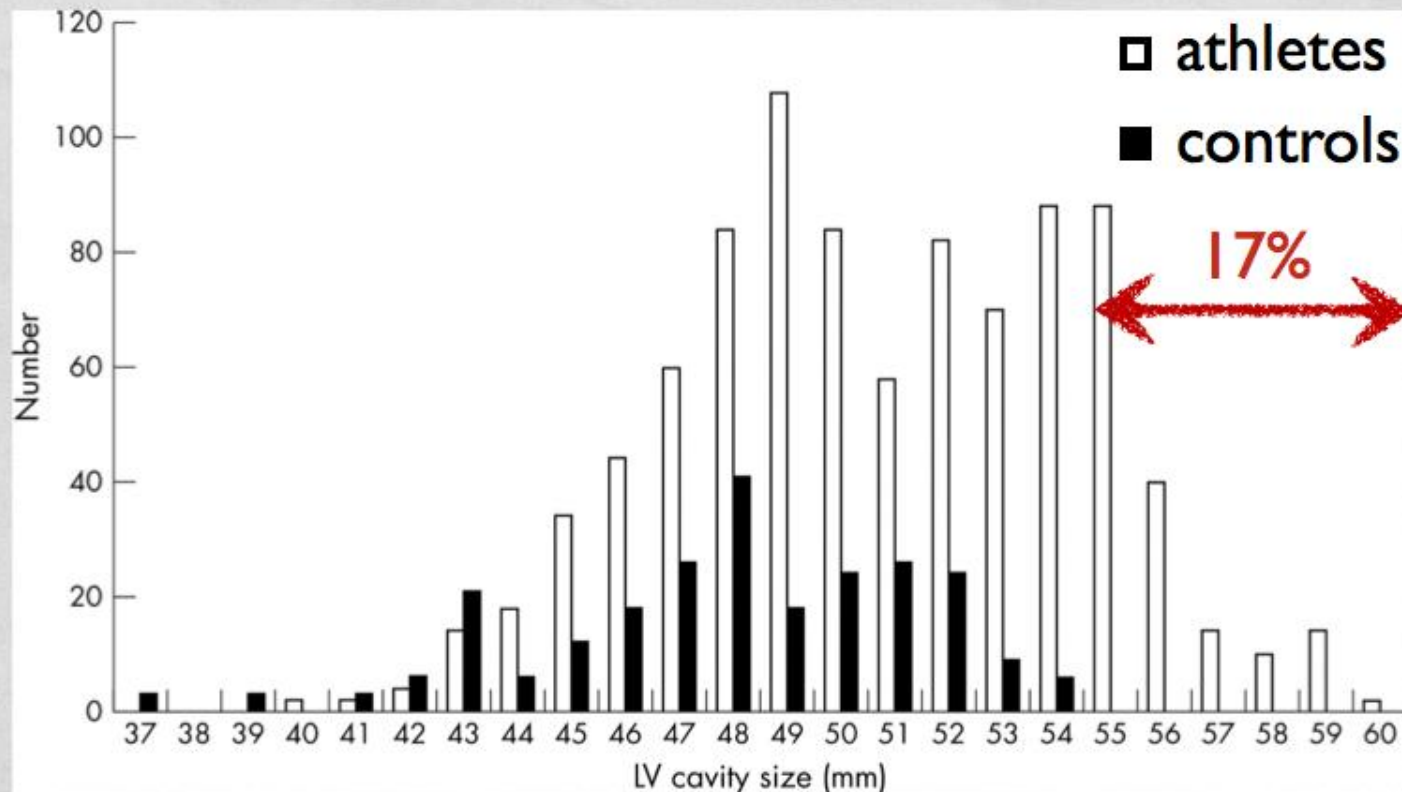
- 900 elite athletes vs. 250 sedentary controls



Makan J et al. Heart 2005;91:495-499

LEFT VENTRICULAR CAVITY SIZE IN ADOLESCENT ATHLETES

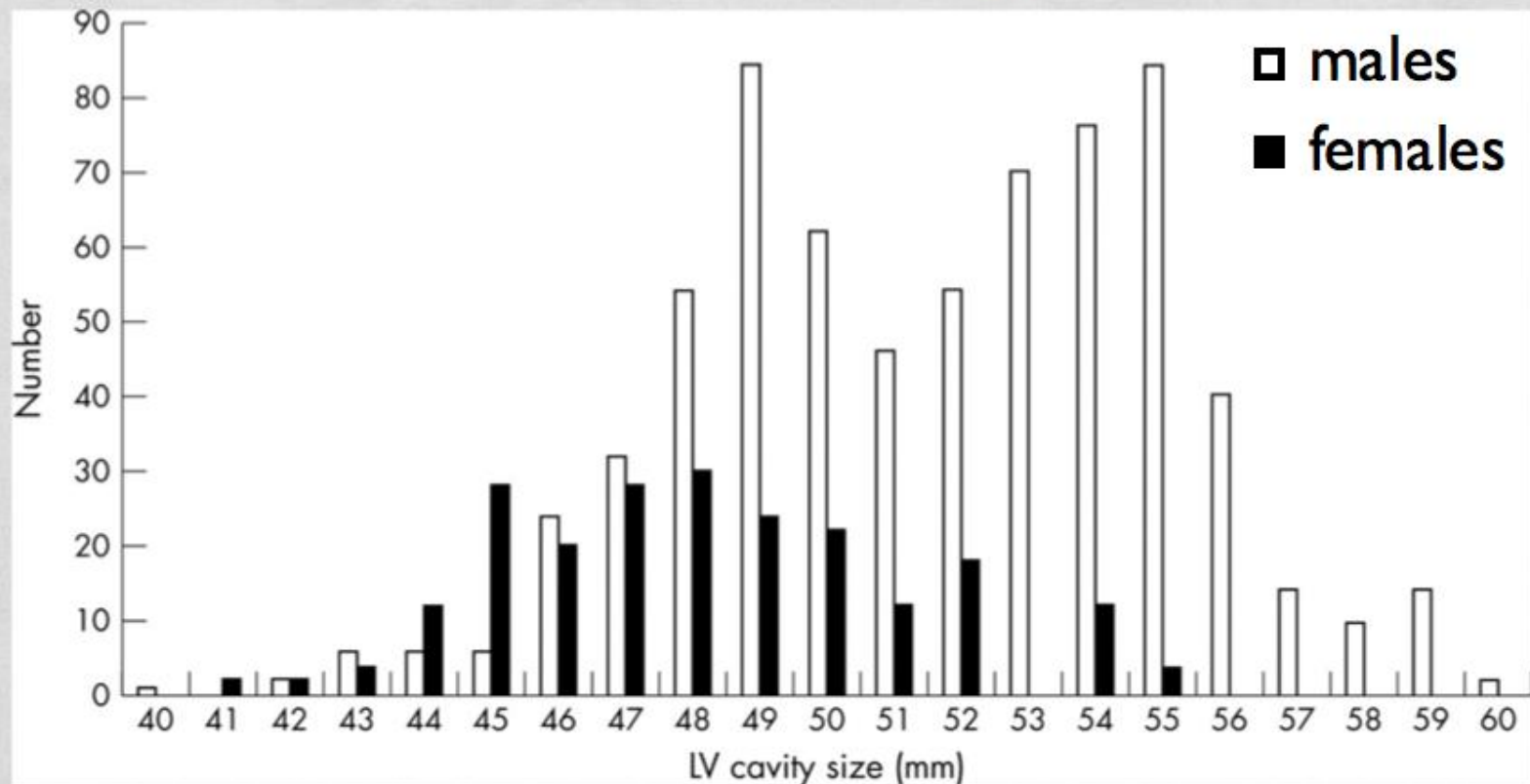
- 900 elite athletes vs. 250 sedentary controls



Makan J et al. Heart 2005;91:495-499

LEFT VENTRICULAR CAVITY SIZE IN ADOLESCENT ATHLETES MALES VS. FEMALES

- 900 elite athletes vs. 250 sedentary controls



Makan J et al. Heart 2005;91:495-499

- All athletes with a dilated LV cavity exhibited normal
 - Systolic function
 - Diastolic function
- In contrast to adult athletes, adolescents athletes
 - Exhibit a maximum LVED of 60mm (70mm in adults)
 - Only 17% exhibiting a LVED $>$ 55mm (45% in adults)

LEFT ATRIAL SIZE

	Athletes n=900	Controls n=250	p-value
LA diameter (mm)	32.7 (19-45)	30.9 (20-40)	< 0.001

	Male Athletes	Female Athletes	p-value
LA diameter (mm)	33.3 (19-45)	31.1 (20-42)	< 0.001

- No evidence of underlying cardiac pathology
- In contrast to adult athletes, adolescents athletes
 - $LA \leq 45\text{mm}$ (50mm in adults)
 - Only 12% exhibiting a $LA > 40\text{mm}$ (20% in adults)

AORTIC ROOT DIAMETER

- Studies in adult athletes have demonstrated Ao dilatation compared to controls
- In adolescents:
 - Sharma S et al. 28.7 (17-40) vs. 27.1 (19-33), NS
 - Somauroo JD et al 29.2 (25-34) vs. 25.0 (21-29), $p < 0.001$

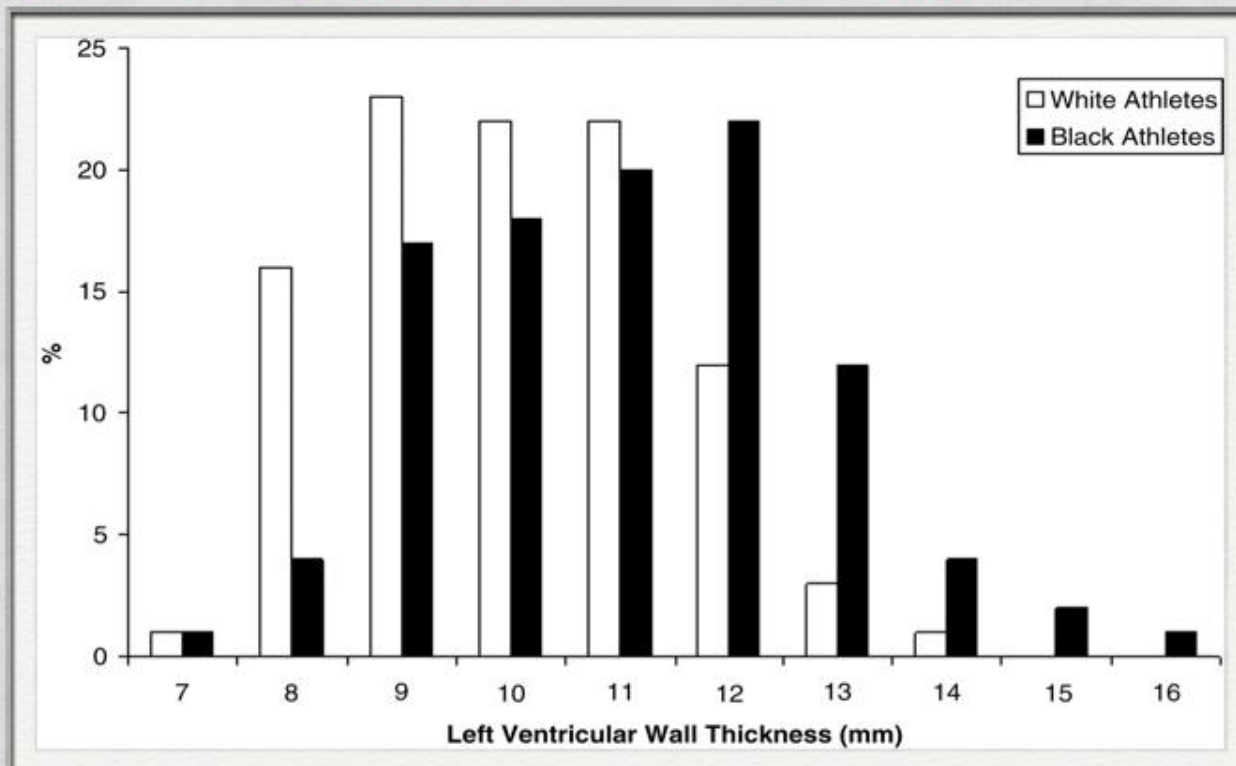
RIGHT VENTRICULAR DIMENSIONS

- Inherent limitations of ECHO with RV assessment
- RV hypertrabeculation in adolescents
- Very limited data in adolescent athletes
- Somauroo JD et al. 172 teenage football players with age and BSA matched controls

RVED 20.8mm (1.55-2.66) vs. 1.07 (0.98-1.62), $p < 0.001$

THE IMPACT OF ETHNICITY

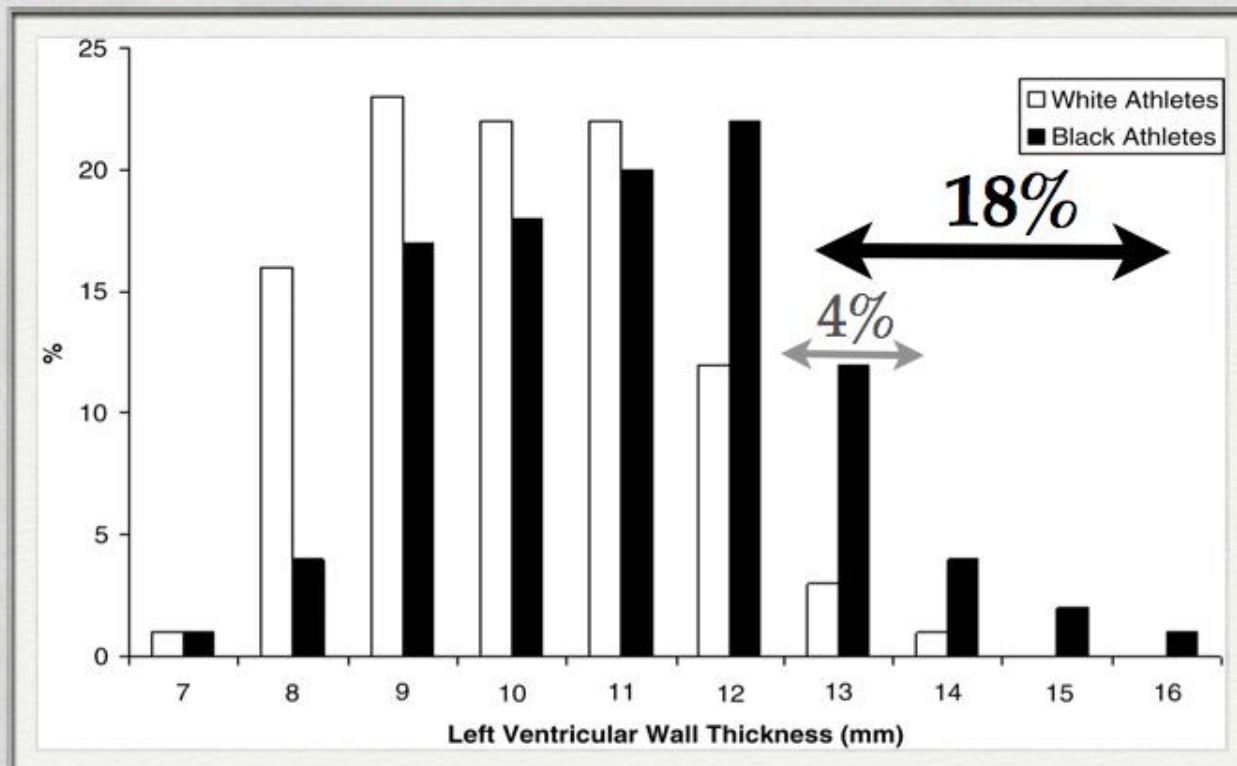
- Adult black athletes exhibit greater degree of LVH and LVM compared to white athletes



Basavarajaiah S. et al JACC 2008;51:2256-2262

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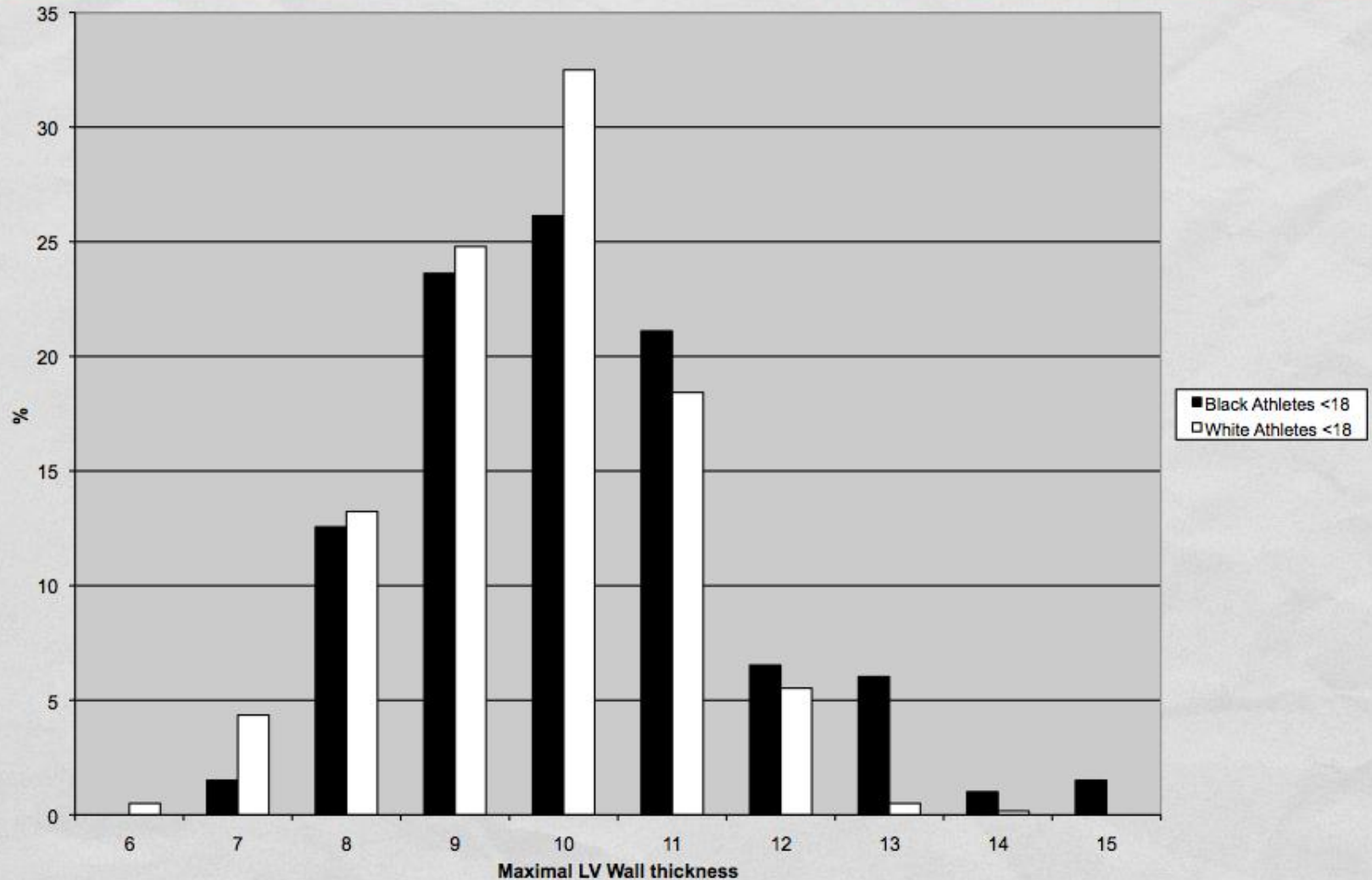
BLACK ADOLESCENT ATHLETES

- Limited data on black adolescent athletes
- 155 elite male football players, aged 14-17 years

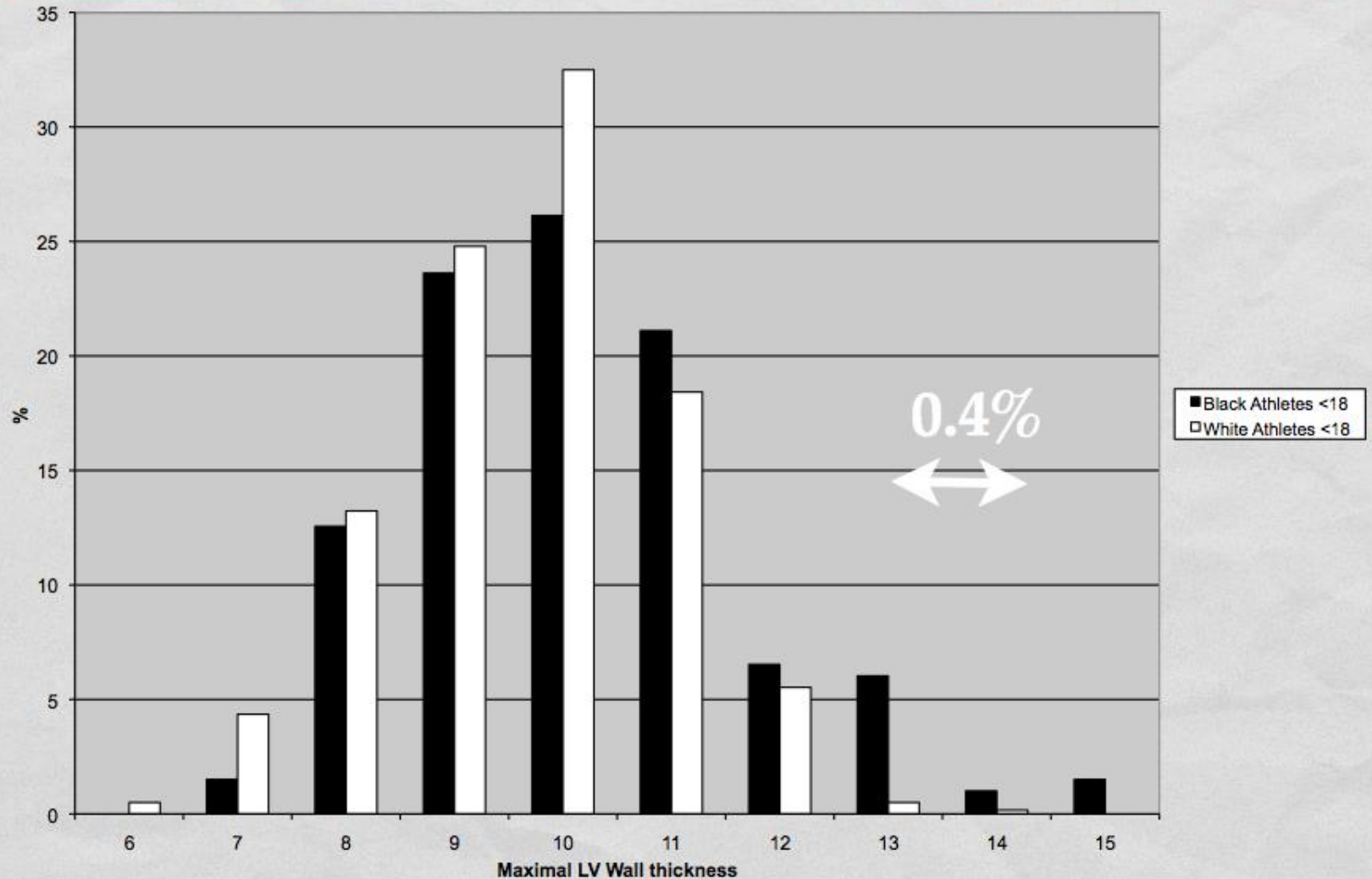
LVED	61.8 mm
max-LVWT	13.2 mm
LA	44 mm
Ao	38 mm

Schmied C et al Br J sports Med 2009;43:716-721

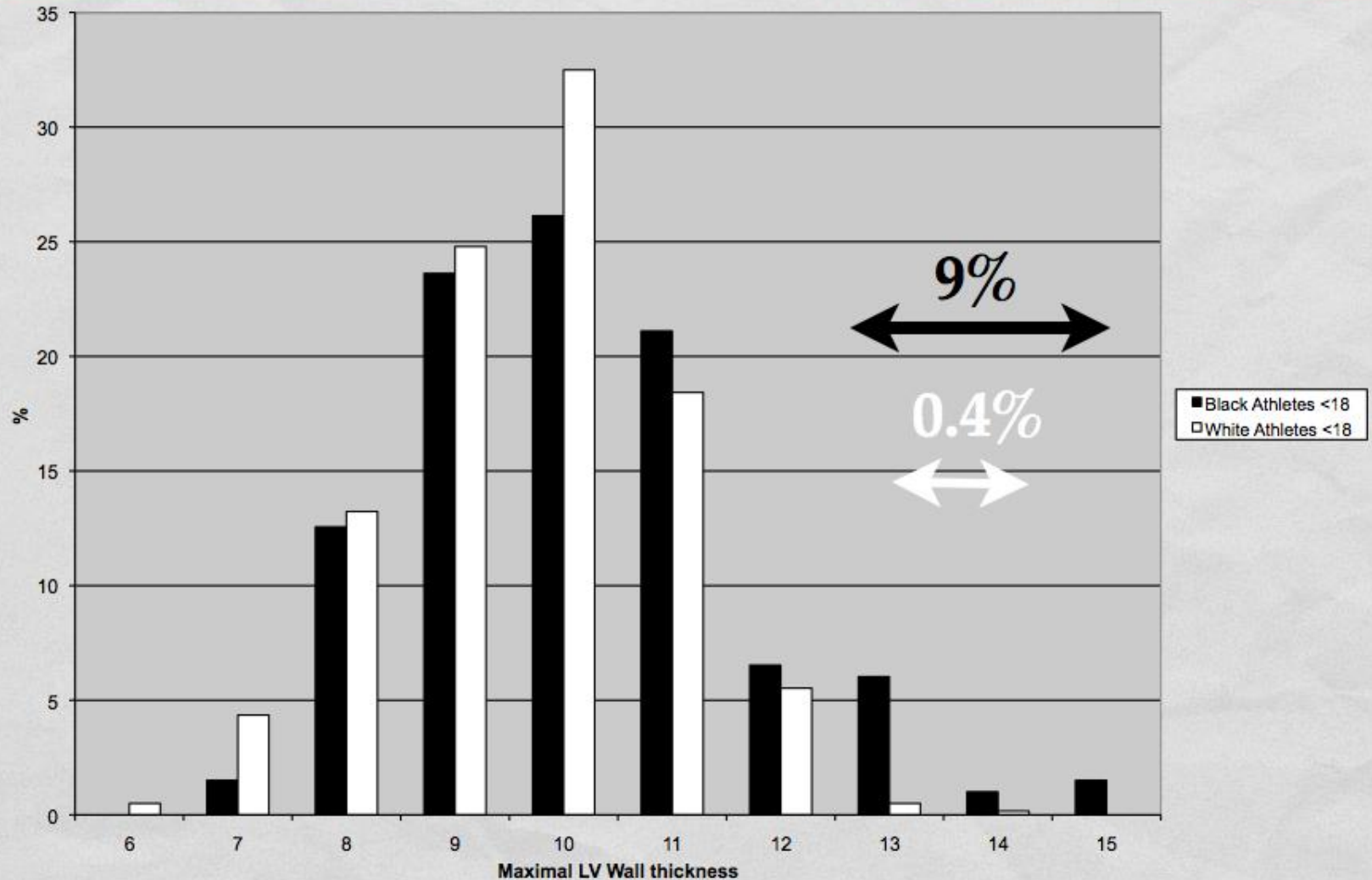
MAX-LVWT IN BLACK ADOLESCENT ATHLETES



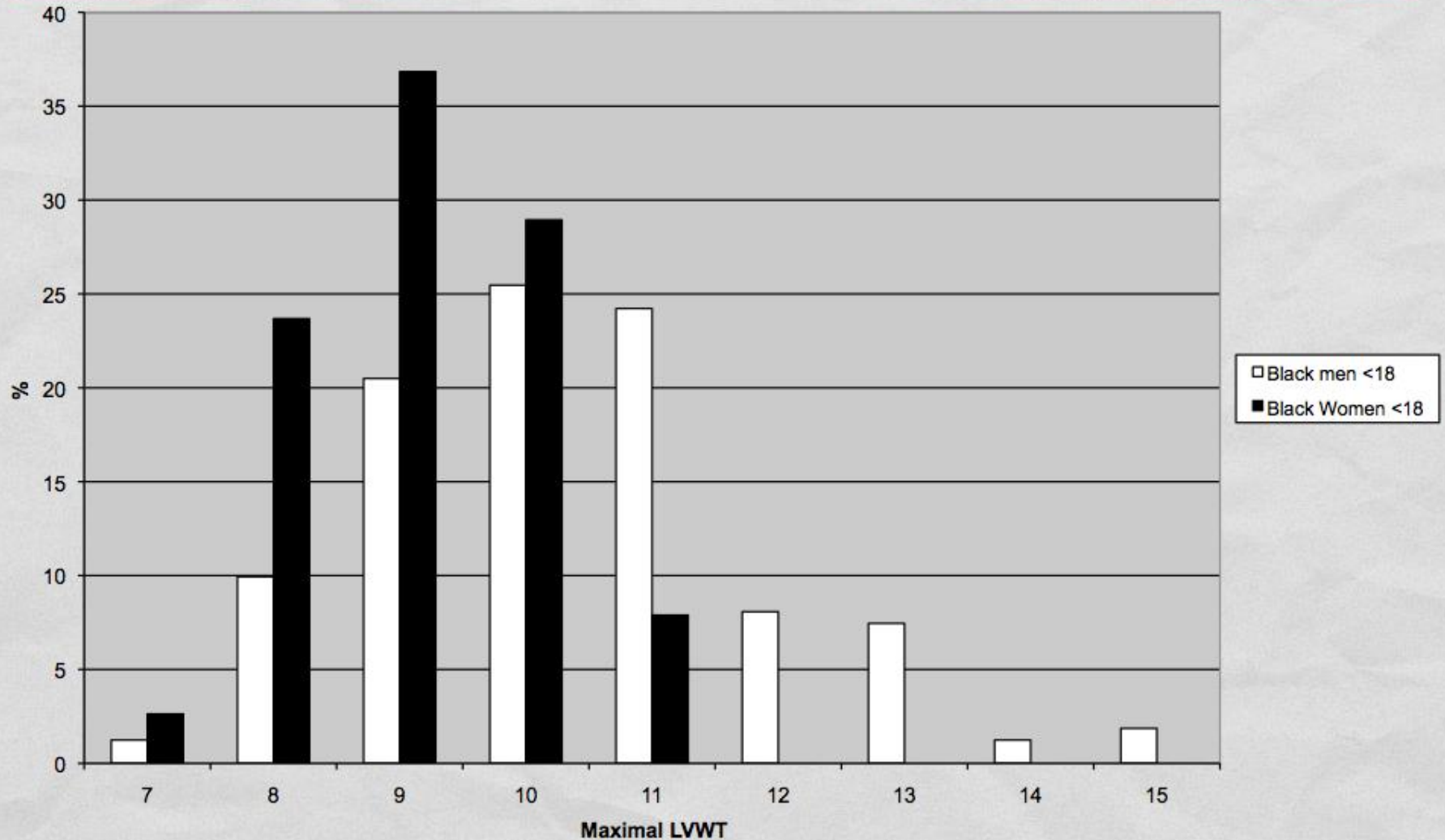
MAX-LVWT IN BLACK ADOLESCENT ATHLETES



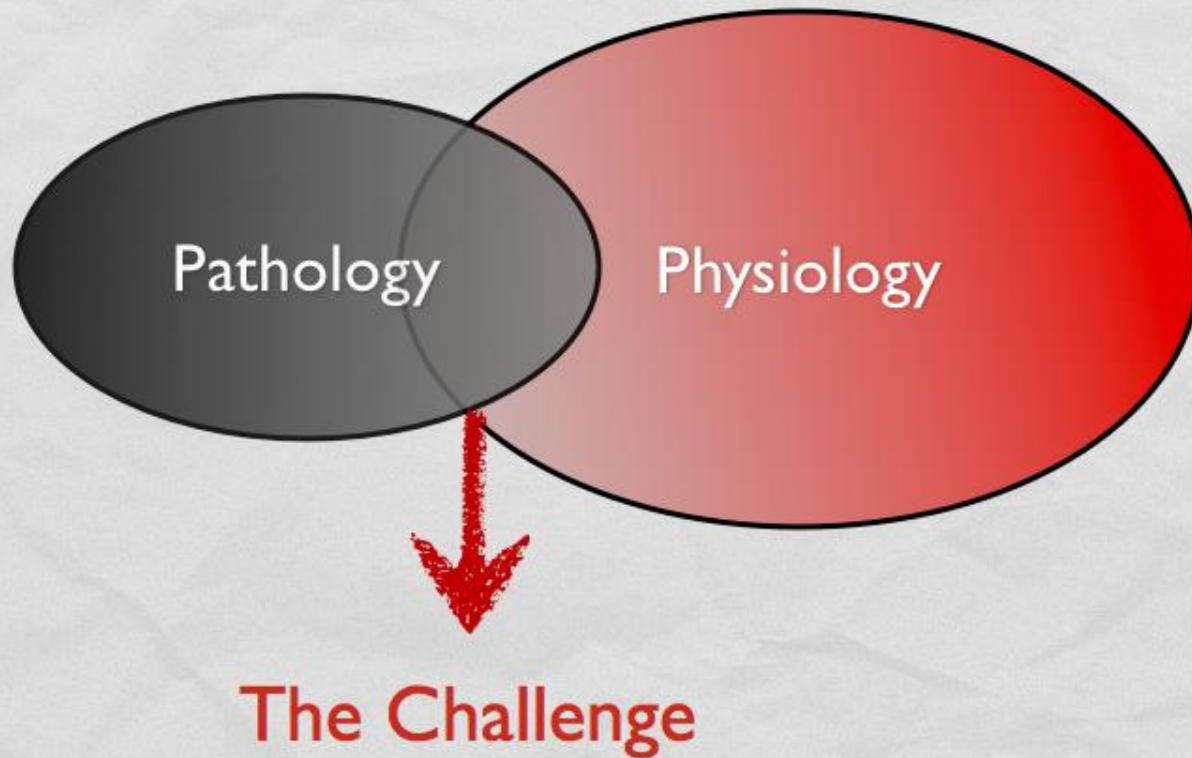
MAX-LVWT IN BLACK ADOLESCENT ATHLETES



MAX-LVWT IN BLACK ADOLESCENT ATHLETES MALES VS. FEMALES



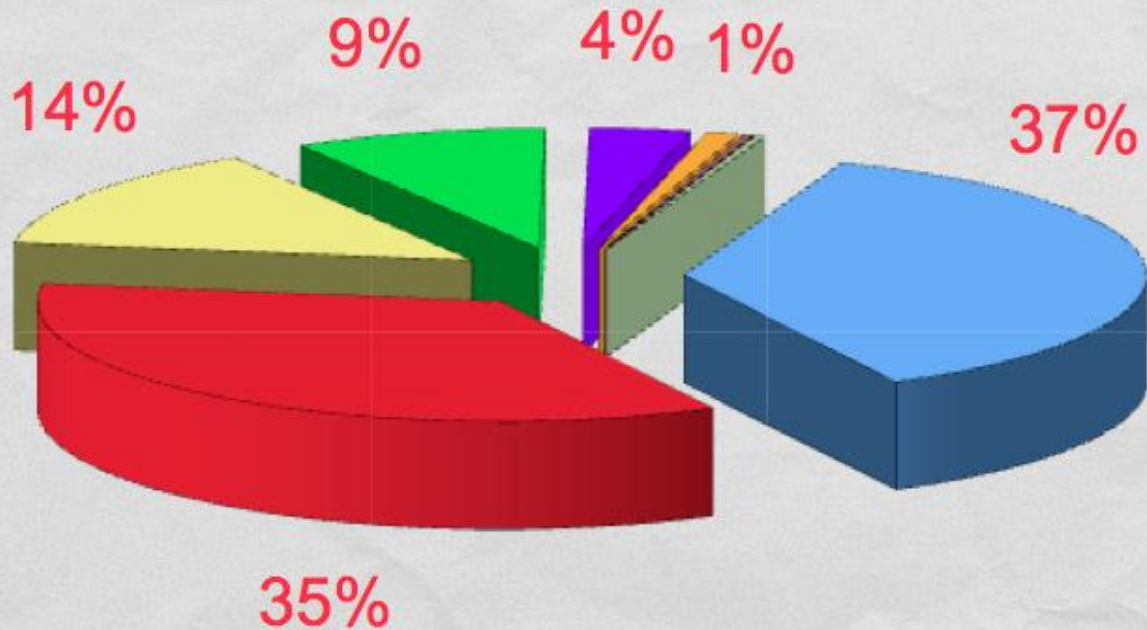
PHYSIOLOGY OR CARDIAC PATHOLOGY?



SUDDEN CARDIAC DEATH IN YOUNG (≤ 35 YEARS) ATHLETES



CAUSES OF SCD IN YOUNG ATHLETES (≤ 35 YEARS)



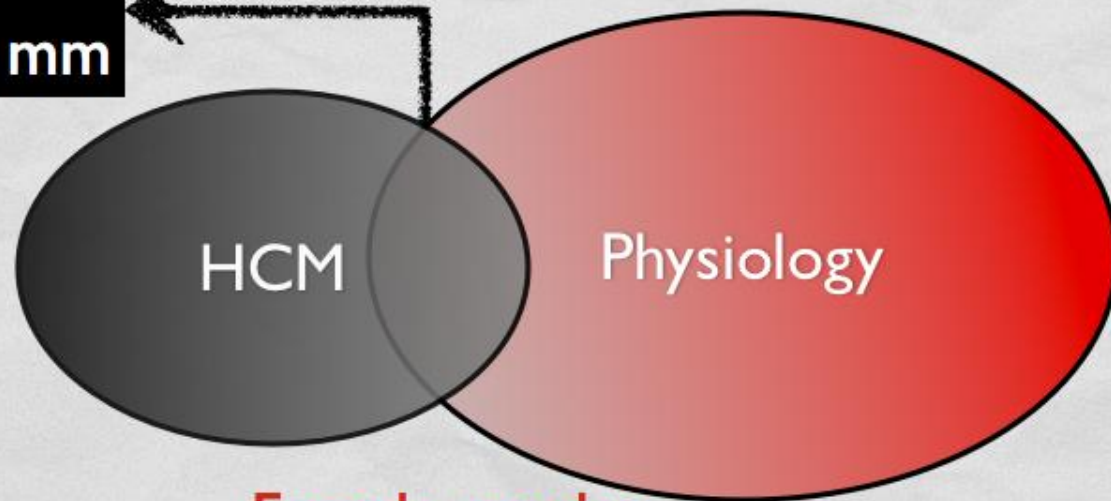
- Congenital + Anatomic
- Cardiomyopathies
- Arrhythmias
- Infectious
- Degenerative
- Undetermined
- Acquired
- "Normal heart"

DIFFERENTIATION OF PHYSIOLOGY FROM PATHOLOGY IN ADOLESCENT ATHLETES

- Clinical & Family history
- Demographics (Gender, Ethnicity, Sporting discipline)
- 12-lead ECG, Holter ECG monitor
- ECHO & other imaging techniques
- Cardiopulmonary exercise testing
- Detraining
- Family screening

ADOLESCENT ATHLETE'S HEART OR HYPERTROPHIC CARDIOMYOPATHY?

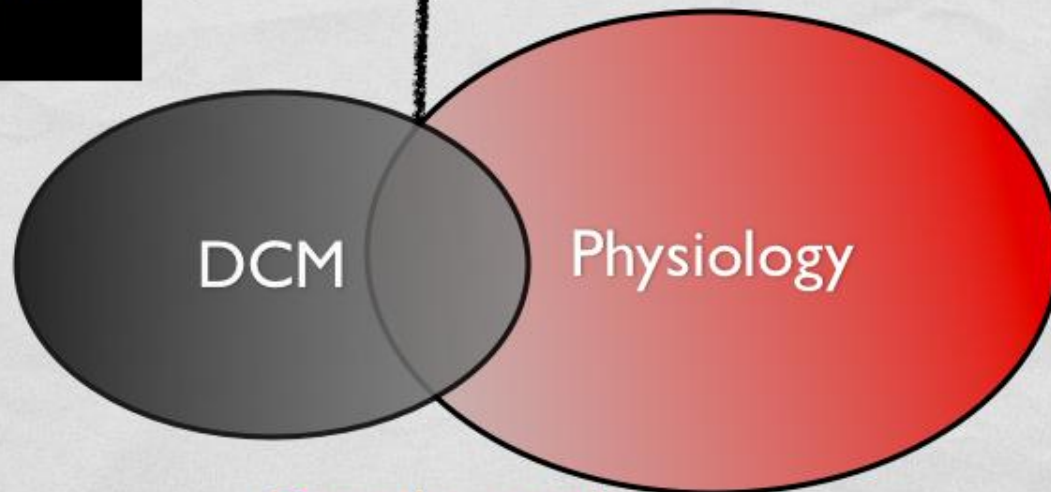
**“Grey zone”
max-LVWT 11-14 mm**



Female gender
Bizarre patterns of LVH
LV cavity < 52mm
LA > 45mm
SAM +/- LV outflow obstruction
Impaired diastolic indices

ADOLESCENT ATHLETE'S HEART OR DILATED CARDIOMYOPATHY

“Grey zone”
LVED 55-60 mm
Reduced EF

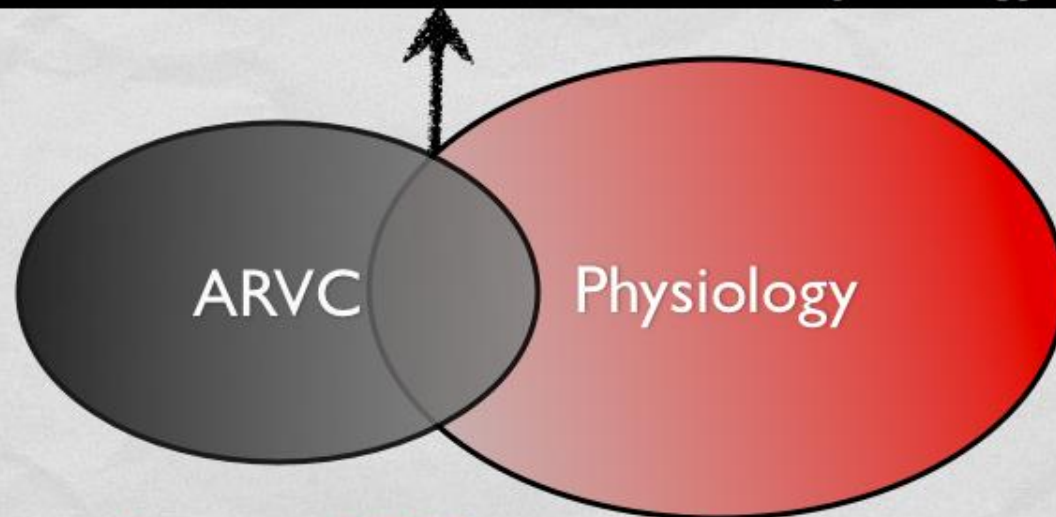


Female gender
LA > 45mm
Impaired diastolic indices
Impaired systolic function on exertion

ADOLESCENT ATHLETE'S HEART OR ARRHYTHMOGENIC RIGHT VENTRICULAR CARDIOMYOPATHY

“Grey zone”

**RV dilatation, RV hypertrabeculation
T-wave ↓ VI-V3, VEs of LBBB morphology**



**Impaired RV systolic function
Impaired LV systolic function
Impaired diastolic indices**



CONCLUSION

- Adolescent athletes exhibit similar cardiac adaptation to adult athletes with increased chamber size and wall thickness
- BUT to a lesser degree compared to adult athletes
- Most athletes exhibit modest increase in cardiac dimensions
- A small proportion of athletes exhibit substantial increase in cardiac size which overlap with cardiomyopathies

- Individuals with:

	Male Athletes	Female Athletes
max-LVWT	> 14 mm	> 11 mm
LVED	> 60 mm	> 55 mm
LA	> 45 mm	> 42 mm
Ao	> 40 mm	> 36 mm

should be further assessed for underlying cardiac pathology

- The vast majority of clinical dilemmas can be resolved with systematic clinical evaluation

THANK YOU !!!