

TRAINING INDUCED RV REMODELING IN PREADOLESCENT ENDURANCE ATHLETE:

THE ATHLETE HEART IN CHILDREN

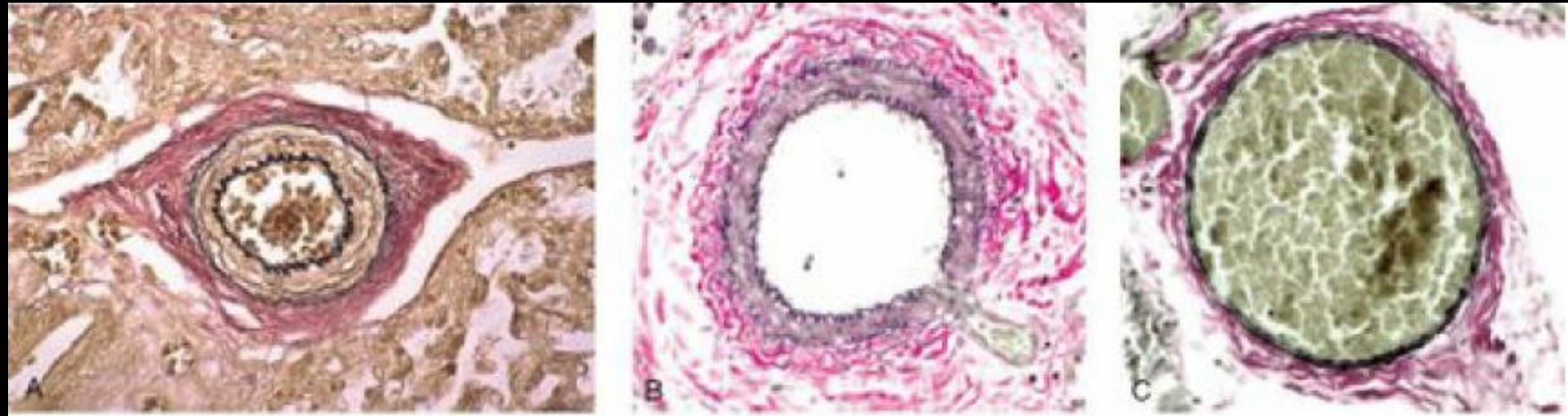
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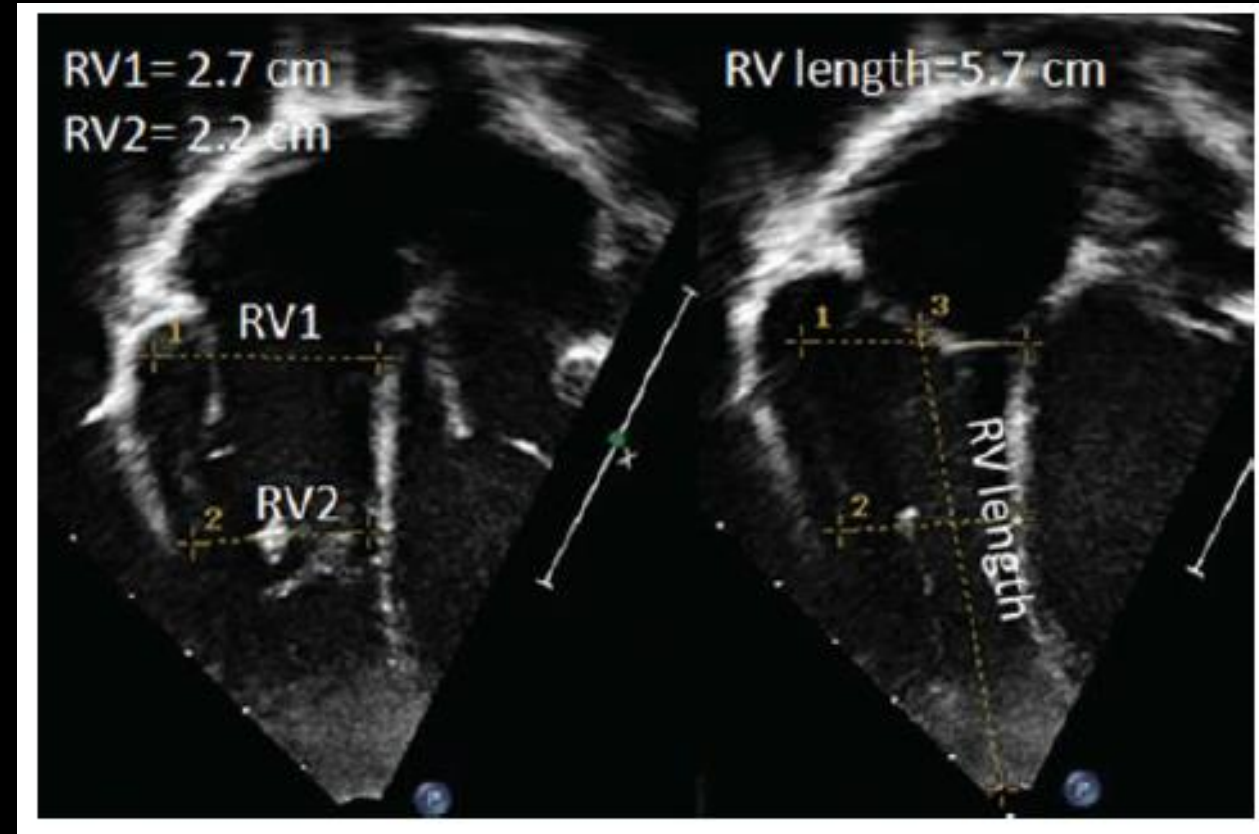
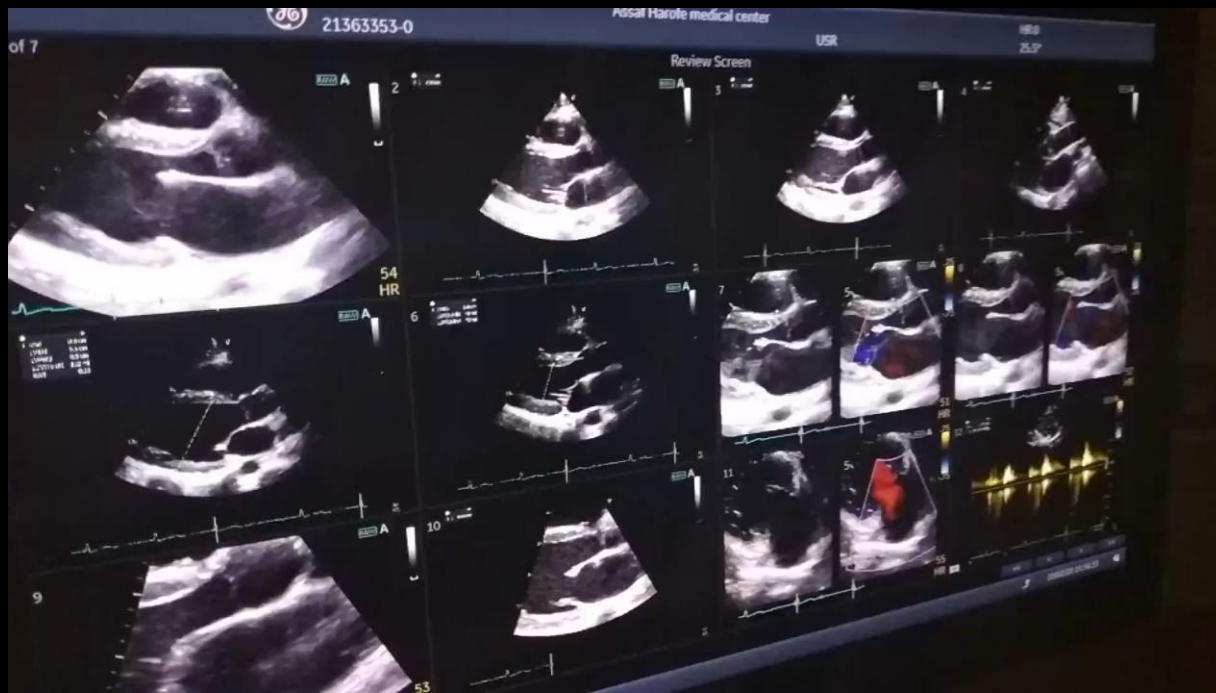


NORMAL PEDIATRIC REMODELING FROM FETUS TO CHILD

- During fetal life, a state of physiologic pulmonary hypertension exists owing to patency of the ductus arteriosus and equalization of aortic and pulmonary arterial pressures.
- As a result, the medial thickness of muscular pulmonary arteries resembles that of systemic arteries.
- After birth, as the ductus arteriosus closes and pulmonary arterial pressure decreases, attenuation of medial smooth muscle occurs, such that the ratio of medial thickness to external diameter decreases from 20% to 25% in fetuses to <10% in infants 3 to 6 months of age



IN THE PEDIATRIC RECOMMENDATIONS, VARIOUS MEASUREMENTS OBTAINED FROM THE APICAL FOUR CHAMBER VIEW HAVE BEEN PROPOSED



Measurement of right ventricular (RV) 2-D dimensions. From the apical four-chamber view, RV width is measured just below the tricuspid valve (RV1) and in the mid part of the RV (RV2). RV length is also measured just after tricuspid valve closure from the mid of the tricuspid valve to the apex of the RV.

ECG CHANGES NEONATE TO CHILD

- The hallmark of the ECG changes in the normal infant and child are the age-related transitions of QRS morphology, QRS duration, and the pattern of the ST segment and T wave
- The right ventricular dominance of the infant is one of the first age-dependent ECG changes to be recognized. The changes in depolarization of the ventricles during the first year of life occur in an orderly progression
- The transition of the ECG from right ventricular dominance at birth to the pattern of left ventricular dominance lags behind hemodynamic changes.
- Loss of right ventricular dominance starts at about 1 month of age, and left ventricular dominance is well established by 1 year


AND WHAT ABOUT PUBERTY....

- Puberty is a period of rapid changes, with large variability between individuals
- Cardiac growth depends on a complex interplay of individual and environmental factors such as sex, body mass, and race
- Superimposing an additional stress such as regular endurance training further increases heterogeneity and complicates the characterization of the heart of children athletes



TAKE THE DIFFERENCE IN GENETICS AND RAISE IT BY ENDURANCE



- 
- In adults, well-known cardiac changes are established as the ‘‘athlete’s heart’’
 - Many different researches and article published about that aspect
 - What about children
 - But first lets overview the physiology

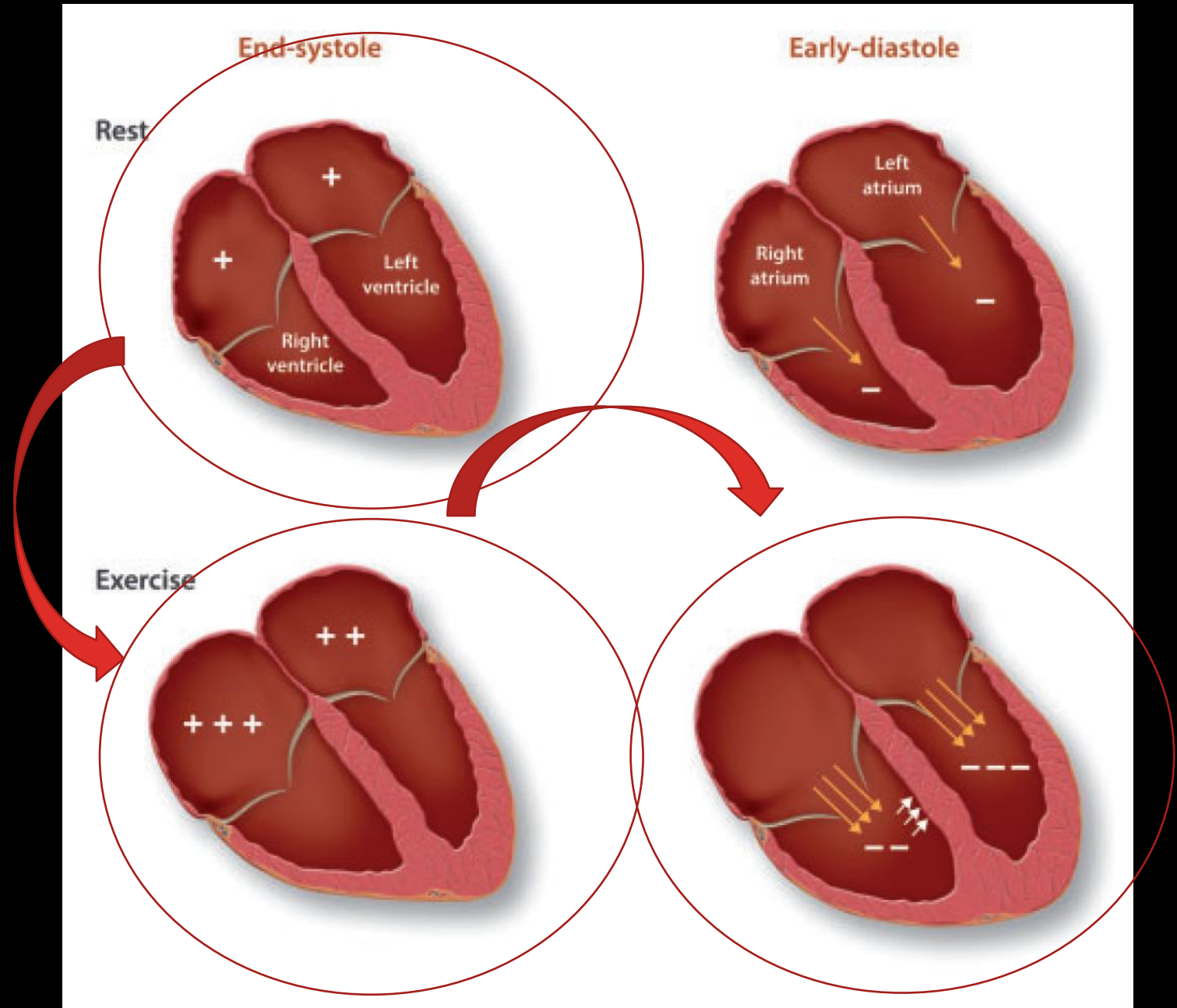
RV REMODELING PHYSIOLOGY

- The RV remodeling occurs in athletes in association with LV remodeling as supported by the positive linear correlation observed between the RV and LV size.
- the balanced biventricular remodeling does not differ among athletes practicing different sports disciplines and that the RV/LV ratio is not influenced by the type of sport.
- A practical implication is the concept that a disproportionate increase, either the RV or LV cavity, should instinctively suggest a nonphysiological remodeling.
- To this regard, a RV/LV ratio <0.9 has been recently proposed as a parameter to distinguish between RV physiological remodeling and ARVC

THE PHYSIOLOGICAL RESPONSE TO EXERCISE

- Immediately after training, the left ventricle (LV) has approximately the same dimensions as before the exercise, LV volumes may be reduced and the LV function slightly impaired.
- In contrast, RV dimensions increase and RV ejection fraction (EF) decreases immediately after exercise, recovering completely to normal during one week after the event
- Considering the Frank-Starling mechanisms, if RV end-diastolic volume (RVEDV) increases immediately after training, RV performance is improved if its contractility is preserved .
- However, an acute and temporary RV dysfunction has been described in studies using echocardiographic deformation imaging The degree of RV function impairment seems to be related to the duration of endurance exercise

- At rest when cardiac flows are low, there are modest atrio-ventricular pressure gradients, low left atrial pressures and low RV pressures.
- During exercise, the high-flow state results in substantial atrial filling and pressure build up during systole when the atrio-ventricular valves are closed
- The resulting increase in left atrial pressures is transferred back through the pulmonary circulation and result in raised RV afterload.
- The increased RV load afterload causes RV dilation (and potentially also some slight delay in RV contraction).
- Because of pericardial constraint, the increase in RV volumes causes septal shift toward the left ventricle in early diastole that has the potential to attenuate early diastolic filling of the LV and further increase left atrial pressures. Thus, increases in RV afterload become a critical constraint during high intensity exercise in healthy subjects.



THE PHYSIOLOGICAL RESPONSE TO EXERCISE

RATIONAL

CO increase leading to higher afterload

+

Pulmonary vasculature already has low resistance, and the capacity to further decrease it is limited .

+

RV maintains the same CO as the LV does, with only limited reduction in afterload

At the expense of maintaining the same CO as the LV, the resulting higher PAP during exercise associated with the limited decrease of pulmonary vascular resistance, leads to a **greater load and stroke work for the RV** than for the LV

All leading to RV remodeling

RECENTLY, AGE- AND BODY SURFACE AREA-ADJUSTED NORMOGRAMS WERE DERIVED FROM A LARGE ITALIAN REGISTRY OF PERI-PUBERTAL FOOTBALL PLAYERS

Cavarretta E, Maffessanti F, Sperandii F, et al. Reference values of left heart echocardiographic dimensions and mass in male peri-pubertal athletes. Eur J Prev Cardiol

Left ventricular diameters did not correlate to training load and were similar to those of non-athletic populations, suggesting little impact of regular physical activity on cardiac remodelling in children

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Sports cardiology

Reference values of left heart echocardiographic dimensions and mass in male peri-pubertal athletes

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Background Several articles have proposed reference values in healthy paediatric subjects, but none of them has evaluated a large population of healthy trained adolescents.

Design The study purpose was to establish normal echocardiographic measurements of left heart (aortic root, left atrium and left ventricular dimensions and mass) in relation to age, weight, height, body mass index, body surface area and training hours in this specific population.

Methods We retrospectively evaluated 2151 consecutive, healthy, peri-pubertal athletes (100% male, mean age 12.4 ± 1.4 years, range 8–18) referred to a single centre for pre-participation screening. All participants were young soccer athletes who trained for a mean of 7.2 ± 1.1 h per week.

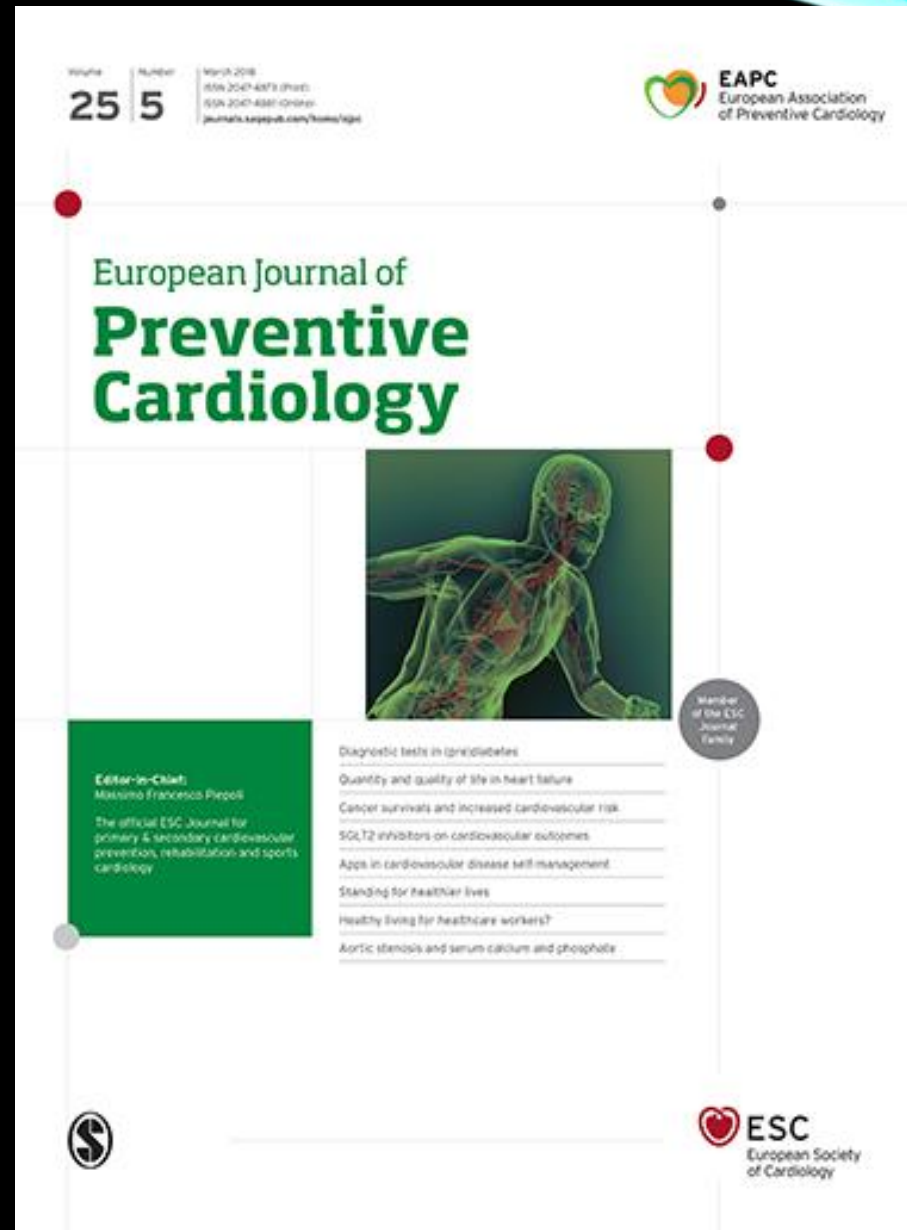
- Conversely, in a meta-analysis including data from 40 studies and over 14,000 young athletes competing in 30 different sports, McClean and collaborators found that....
- The pediatric athlete's heart undergoes significant remodeling both before and during maturational years



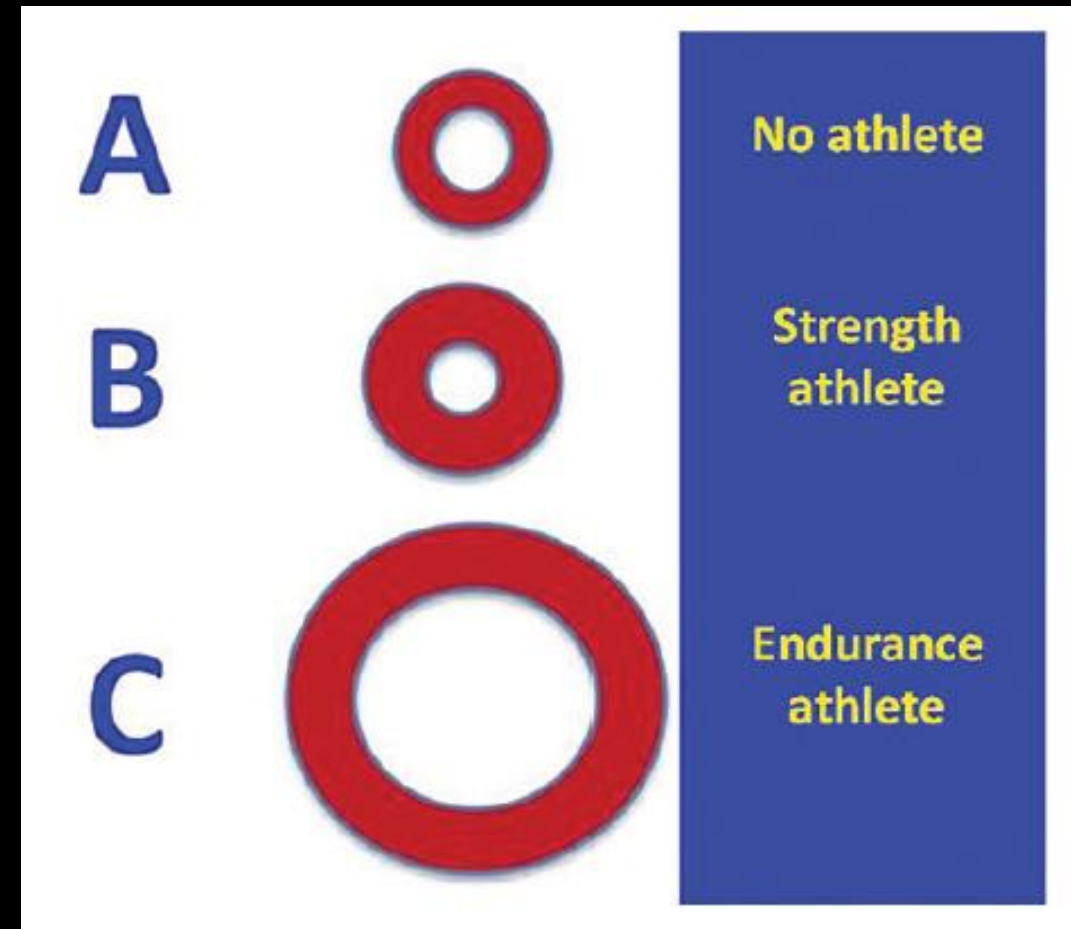
Sebastian Sarvari leading The Norwegian group published Eur J Prev Cardiol 2018 the cardiac remodeling occurring in endurance trained children by mean of 3D echocardiography and strain measurements.

They studied 76 preadolescent cross-country skiers at a national level, (aged 12.1 ± 0.2 years)

Their Conclusion was that Athletes had **greater left ventricular mass and greater left and right ventricular chamber dimensions** compared with control

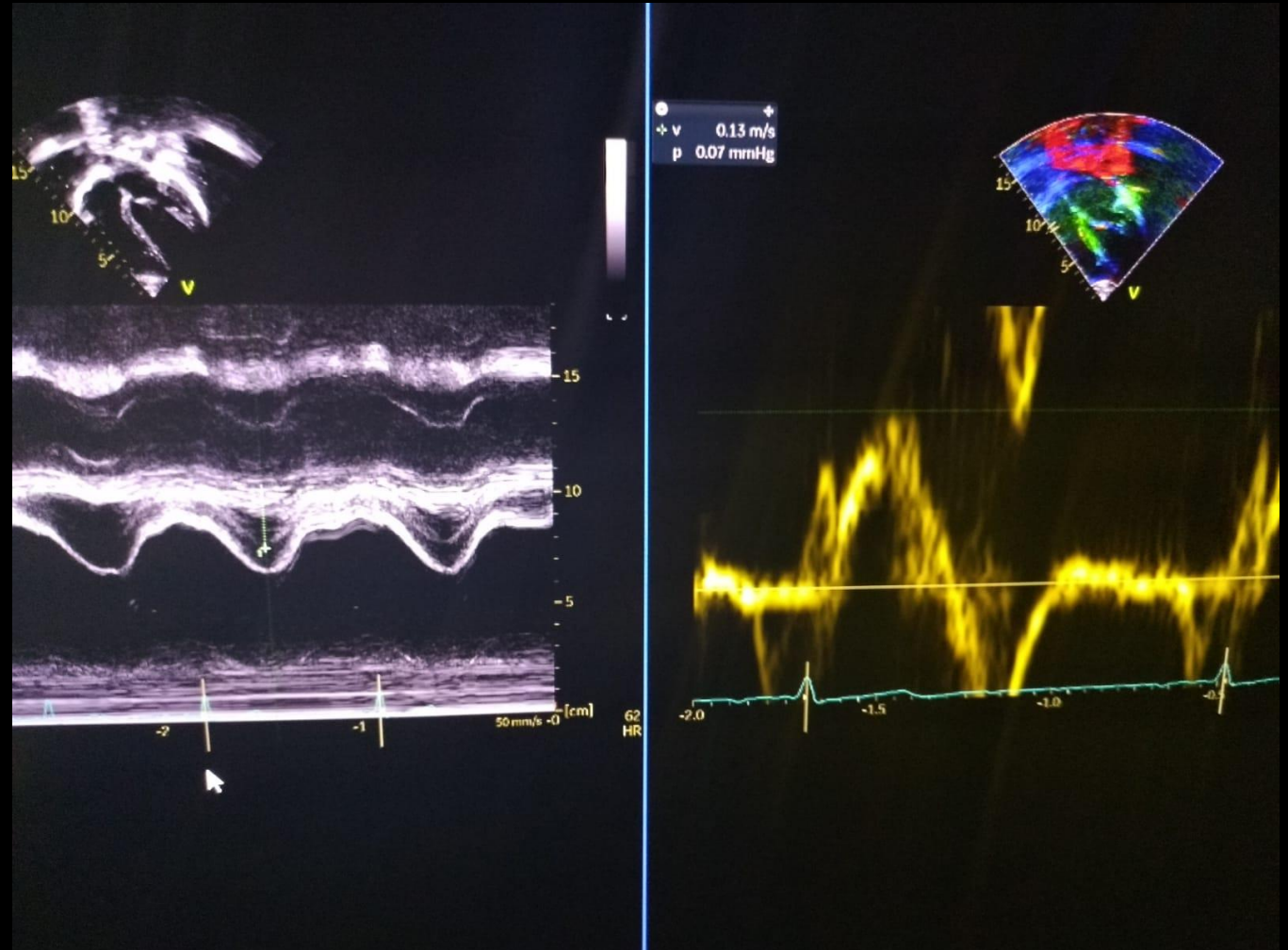


- In July 2019 the same group report at the European Journal of Preventive Cardiology follow-up data on those 48 individuals attending a second evaluation three years after baseline
- At follow-up the active endurance athletes had greater three-dimensional indexed LVED (8411 mL/m² vs. 7910 mL/m², P<0.05) and LVES volumes (366 mL/m² vs. 323 mL/m², P<0.05)
- Those who remained active improved their physical fitness to a larger degree, decreased heart rate at rest, and presented with LV dilation in comparison to those who abandoned regular endurance training.
- Is this evidence of the Morganroth hypothesis?



WHAT ABOUT THE KNOWN EFFECT OF RV REMODELING ALONE

- At follow-up, while there was a “trend” for RV dilation regression in former athletes, the RV function measured with global longitudinal strain (GLS) remained similar to those who remained competitive the RV is an increasingly recognized player and a powerful predictor of cardiac fitness



F. D'ASCENZI AND HIS GROUP FROM SIENA

- presented at the *European Heart Journal*, August 2017 the evaluation of **57 male competitive swimmers** (mean age 10.8 ± 0.2 years)
- just before and after 5 months of intensive training
- concluded that RV physiologic remodelling occurs in the early phases of the sports career, and in children engaged in endurance sports the increase in RV dimensions associated with normal RV function should be considered as **early physiological expression of the athlete's heart**.



SO THE MORPHOLOGICAL CHANGES ARE UNDERSTOOD.....WHAT ABOUT THE ELECTRICAL ONES

European Heart Journal Advance Access published November 17, 2015



European Heart Journal
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CLINICAL RESEARCH

Sports cardiology

Electrocardiographic anterior T-wave inversion in athletes of different ethnicities: differential diagnosis between athlete's heart and cardiomyopathy

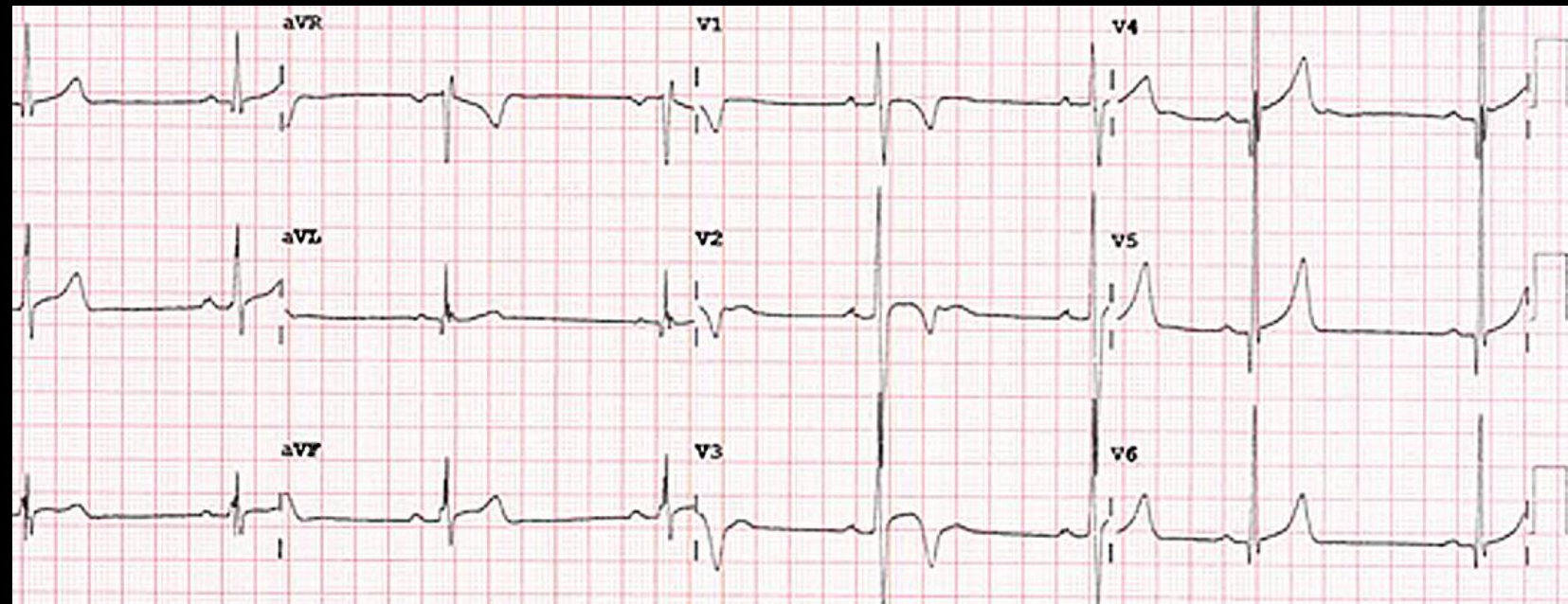
**Chiara Calore^{1†}, Alessandro Zorzi^{1†}, Nabeel Sheikh^{2†}, Alberto Nese¹,
Monica Facci¹, Aneil Malhotra², Abbas Zaidi², Maurizio Schiavon³,
Antonio Pelliccia⁴, Sanjay Sharma^{2‡}, and Domenico Corrado^{1‡*}**

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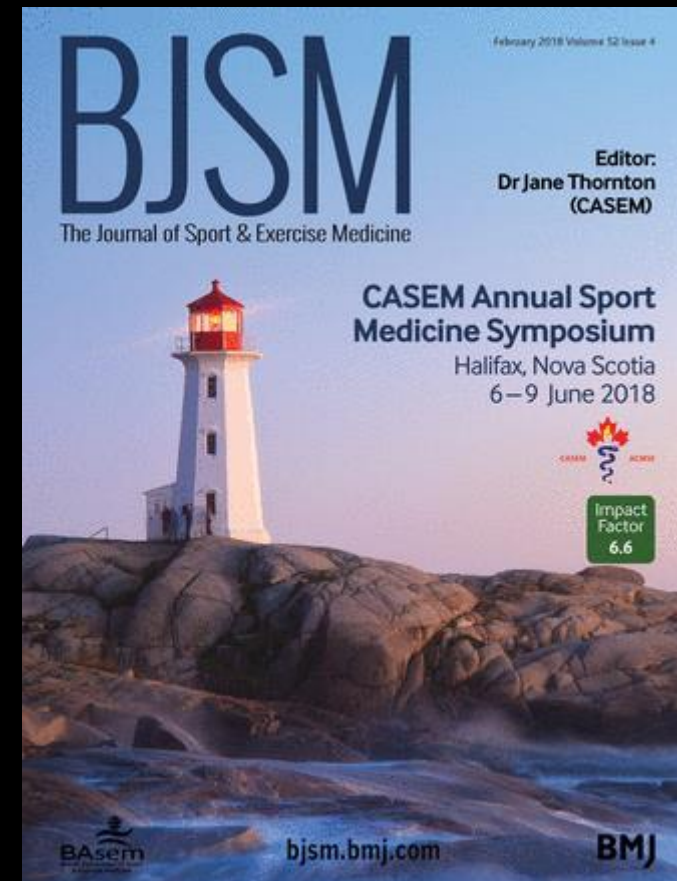
ANTERIOR TWI

- Reported in up to 11% of healthy adolescent athletes .
- Regarded as a pre-pubertal variant or “juvenile” ECG pattern in the absence of symptoms or family history with a cutoff of 16 y.o or puberty for this ECG label
- Right ventricular dominance and predominant posteriorly directed repolarisation in young teenagers may explain this phenomenon



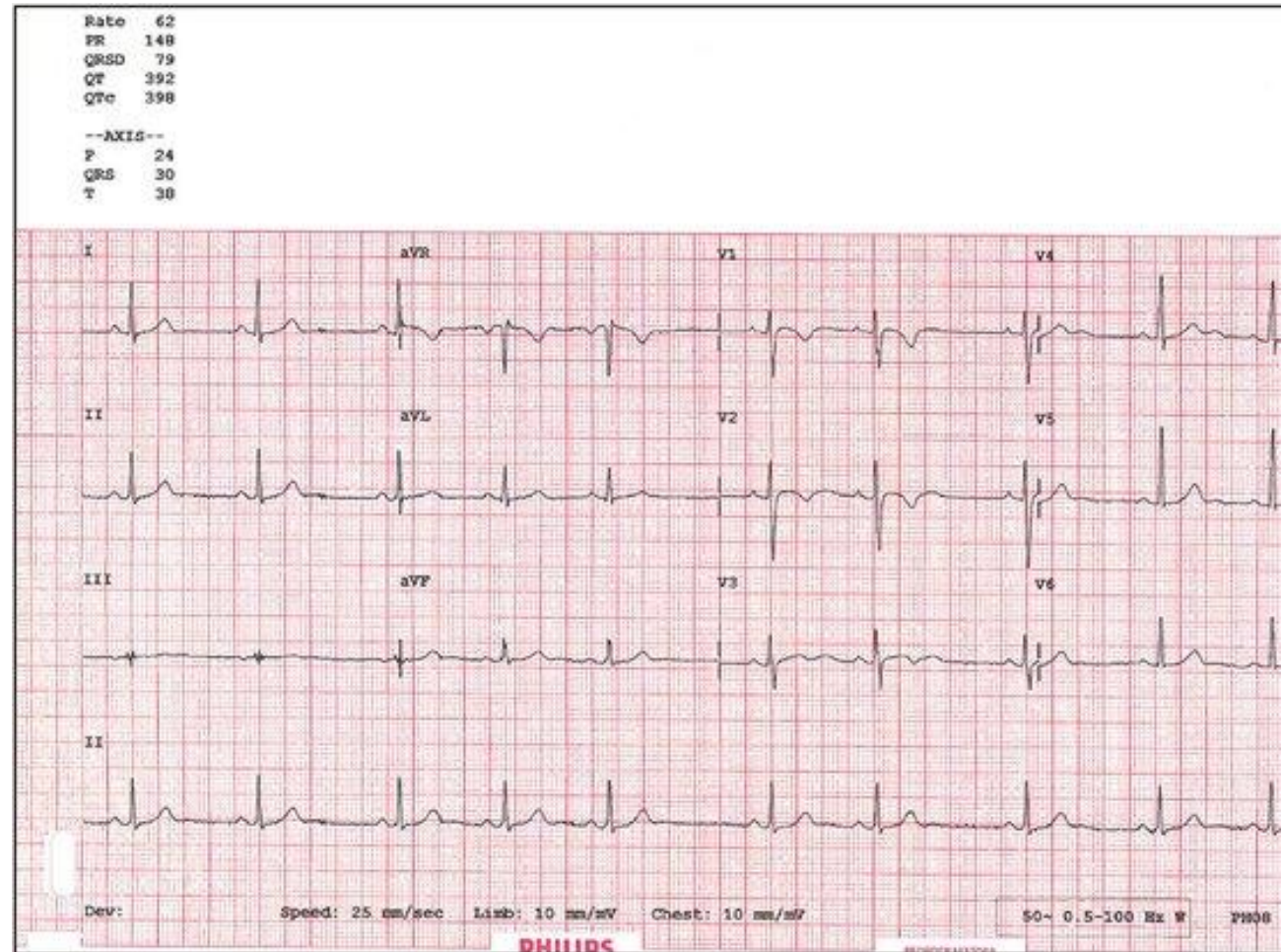
Electrical and structural adaptations of the paediatric athlete's heart: a systematic review with meta-analysis published by McClean et al British Journal of Sports Medicine 2018

Describing the electrocardiographic (ECG) and echocardiographic manifestations of the paediatric athlete's heart



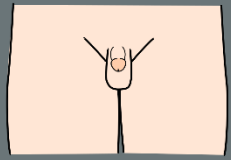

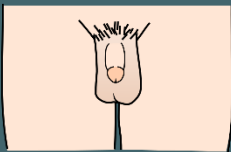


CHANGES IN T WAVES... CHILDHOOD PUBERTY AND ATHLETE

- Athletes ≥ 14 years were 15.8 times more likely to have inferolateral T-wave inversion than athletes < 14 years.



AND WHAT ABOUT OUR EXPERIENCE

- As we all know in pediatric athletes there are huge changes during adolescent that are not age dependent but TANNER dependent
- **ECG of young post pubertal athletes tend to look like prepubertal**
- **While echo of pre pubertal athletes looks like post pubertal with all the ATHLETE HEARTS modifications**

I		3 \updownarrow <2,5
II		4 \updownarrow 2,5-3,2
III		10 \updownarrow 3,6
IV		16 \updownarrow 4,1-4,5
V		25 \updownarrow >4,5



1 unfinished job(s) in Spector

02/01/20 15:32:47

THANKS TO THE PADOVA GROUP FOR ALL THE EFFORT INVOLVED



A red, heart-shaped cushion with a floral and button pattern, floating in the air over a street scene. The cushion is the central focus, with its vibrant red color and intricate gold and yellow floral and button designs standing out against the blurred background of a city street. The background shows a yellow building, a black car, and a stone wall, all slightly out of focus to emphasize the heart-shaped cushion.

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- P3991 | BENCH Athlete's heart in children: exercise-induced right ventricular remodelling in preadolescent athletes- F. D'Ascenzi¹ et al
- **Right ventricular remodeling in athletes and in arrhythmogenic cardiomyopathy**
Journal Scandinavian Cardiovascular Journal
- Volume 52, 2018