Heart Health in the Endurance Athlete
JoEllen Kohlman-Petrick MD

Program objectives

- Discuss physiologic changes that occur with endurance training
- Review potential cardiac conditions that can result in above changes
- List potential treatment strategies and their pitfalls in the endurance athletes
Physical activity

- Routine exercise possesses many traits of a powerful medication
- Stimulates many beneficial physiologic changes in the body
- Cost effective
- Highly effective for prevention and treatment of many prevalent chronic diseases
- CAD, HTN, heart failure, obesity, depression, and DM
- People that exercise regularly live 7 years longer than sedentary individuals
- But is there an upper dose limit beyond which the risks may outweigh benefits?
- Musculoskeletal trauma, metabolic derangements, CV stress

What is the ideal dose of exercise

- Per Harvard Alumni study:
  - 2000-3000 cal/week or 300-400 cal/day
- Per American College of Cardiology
  - 150 minutes per week

Dose response of exercise?

- Modest amount of exercise = substantial health benefits (as little as 15 min a day)
- Benefit plateaus at 50-60 min
- Endurance athletes often exercise for several hours a day, approximately 5-10x greater than recommended for prevention of heart disease
Dose response of exercise?

- 15 year observational study of 52,000 adults
- Runners had 19% lower risk of all-cause mortality compared to non-runners
- U-shaped mortality curves for distance, speed, and frequency
- Running distances of 1 to 20 miles per week, speeds of 6-7 mph and frequencies of 2-5 days/week associated with lower all-cause mortality
- Higher mileage, faster paces, and more frequent runs were not associated with better survival

So is endurance training safe?

What is the definition of an endurance athlete?

One that exercises at least an hour a day training for an event that will take at least 3 hours of continuous exercise to complete
Endurance sports are increasing in popularity

- In 2017, 511,308 people completed marathons in the US in 616 different races.
- In 2017, 182,720 people completed an Ironman event.

Animal models of endurance training

- Rats were trained to run strenuously and continuously for 60 min/day for 16 weeks.
- Running rats developed LV and RV hypertrophy, diastolic dysfunction, and biventricular enlargement.
  - Increased collagen deposition and fibrosis in both atrial and ventricles.
  - Ventricular tachycardia was inducible in 42% of running rates vs 6% of sedentary rates.
- Once rats stopped running, these changes regressed to normal in 8 weeks.

Athlete’s Heart

- With endurance exercise, skeletal muscle O2 demand increases, resulting in increased HR, SV, pulmonary ventilation, BP, peripheral vasoconstriction, and central vasodilation.
  - Ultimately leading to increased cardiac output.
- Chronic exercise training with its increased hemodynamic demands alters loading conditions in the heart.
  - Long distance running, rowing, swimming, cycling, and cross-country skiing.
- Highly trained athletes develop cardiac adaptations to these demands.
  - Often reversible after duration/intensity of exercise is decreased but in some (often elite) athletes, cardiac adaptations do not completely regress.
Structural remodeling during exercise

- Cardiac output increases from 5 L/min to 25 L/min during vigorous exercise
- "Cardiac fatigue" noted where CO decreases during endurance event which can last several days post event
- 10% Tour de France cyclists found to have transient LV dysfunction
- Long term daily sessions of hours of continuous strenuous physical activity cause cardiac remodeling
- Initially these changes are seen to regress during post exercise period...but over time chronic changes can occur known as the Athlete’s Heart

Athlete’s Heart

- Enlarged left and right ventricles
- RV dysfunction due to elevated pulmonary artery pressures
  - Up to 80 mm Hg
- Increased LV thickness and cardiac mass
  - Eccentric
- Increased left atrial size
- Patchy myocardial fibrosis in response to repeated intense overload and excessive cardiac strain
- More common in athletes with the largest cumulative experience in competitive endurance events
- Leading to 5-6 fold increase in cardiac output and reduced resting heart rates
Athlete's heart has a dangerous liaison with cardiomyopathy.
Olympic athletes studied...

- 114 endurance Olympic athletes followed for 4-17 year period
- No association of training with decreased LV function, or occurrence of CV symptoms/events
- Strengthened argument of safety of endurance training even at the highest competitive level

Vascular changes

- Could the shear stress caused by endurance training cause fibrotic changes in the vascular system and decrease arterial wall elasticity?
  - Possibly due to large quantities of free radicals that outstrip buffering system leading to oxidative stress and damage
  - A study of 47 endurance athletes found their aortic stiffness was significantly higher than control group yet another study showed decrease in wall thickness
  - Clinical implication of this is currently unknown
  - It is well documented that endurance training decreases blood pressure and peripheral arterial resistance

Vascular changes

- Acute, intensive exercise causes transient hypercoagulable state due to increased thrombin, platelet hyperreactivity, and increased activity of several coagulation factors
- But regular endurance training show a decrease in fibrinolytic activity thus potentially protecting endurance athletes from DVTs and PEs
Coronary artery changes

- One study showed marathon runners had greater coronary artery dilating capability than non-runners.
- Another study of 108 German marathon runners observed a greater atherosclerotic burden in the marathoners with higher coronary artery calcium scores.
- Several other studies have shown similar results.
  - Yet CV event rates were the same in runners vs non-runners.

Biomarker evidence for cardiac damage

- Serologic markers of cardiac damage have been documented to increase in up to 50% of participants during and after a marathon, 11% in cross country skiers and 9% in Ironman athletes.
  - Troponin, CK-MB, and BNP
  - This may reflect myocardial cell damage.
  - Levels normalize in 24-48 hrs post event.
  - Transient renal dysfunction also noted with elevated BUN and Creatinine.
  - Unknown mechanism but a popular theory suggests heightened adrenaline levels cause coronary artery constriction leading to cell death.
  - Significance of this remains unknown.

Common EKG findings in Endurance Athletes

- SVT, atrial fibrillation
- Rate arrhythmias
- Congenital defects
- PACs/PVCs
- Early repolarization of ST segment
- LVH criteria
- P wave
- QT prolongation
- RVH
- Sinus bradycardia
- Sinus arrhythmia
- Conduction delays
- PACs/PVCs
- Left ventricular hypertrophy
- T wave inversions
- ST depression
- QT prolongation
Proarrhythmic effects of endurance training

- Cardiac remodeling can create an arrhythmogenic substrate
- Due to increased vagal and sympathetic tone, bradyarrhythmias, inflammatory changes, atrial wall thickness and increased atrial size
- Rhythm abnormalities are the most common CV problem in veteran endurance athletes
- Driven by AF and bradyarrhythmias, no increase in SVT/VT/VF noted in recent large study of long distance XC skiers

Atrial fibrillation

- Veteran endurance athletes have been noted to have a 5-fold increase in prevalence of atrial fibrillation
- No trial or guideline exist to specifically address treatment and prognosis in AF stricken endurance athletes
- Antiarrhythmics/AV nodal blocking agents often not well tolerated, so ablation is often treatment of choice for athletes
Sudden cardiac death

- Among marathoners rate of SCD is 1 per 100,000 participants
- 1:50,000 for non fatal cardiac event such as MI
- Despite low rate, can have a disproportional impact on society
- This rate has not changed, but since more people are participating in marathons the event rate is increasing
- Fatality rate for triathlons is 2x that of marathons due to increased events and drownings during swim portion

Sudden cardiac death

- One epidemiological study showed that marathons reduce death toll because the average number of race associated SCDs is about 1/2 the number of deaths that would typically result from motor vehicle crashes if the race routes were not closed to traffic
Sudden cardiac death

- In athletes younger than 30, the cause of SCD is using genetic causes such as hypertrophic cardiomyopathy, anomalous coronary arteries, dilated cardiomyopathy and congenital long QT syndrome
- In athletes older than 30, acute myocardial infarction are the predominant cause
Coronary artery disease

- As more people participate in endurance events, the number of athletes with CAD is also increasing
- No clinical trial exist focusing on appropriate exercise prescription for endurance athletes with CAD
- Post stent or CABG, it is considered reasonable to complete cardiac rehab program followed by exercise stress testing to determine future training plans
- Pharmacologic treatments often affect performance including beta blockers and statins
- Must incorporate shared decision making approach with athletes

Yet no long term studies in professional endurance athletes show an increased cardiovascular event rate

A recent study of Tour de France participants showed a significantly lower cardiovascular event rate and prolonged life expectancy compared to age matches “ordinary” men

Twin Cities Marathon study

- Included 50 men that participated in at least 25 consecutive Twin Cities marathons
- Scanned for coronary artery calcification
- Collectively ran 3,510 marathons (27 to 171 per subject)
- 16 had no plaque in arteries, 12 with slight amounts, 12 with moderate amounts and 10 with worrisome large deposits of plaque
Twin Cities Marathon study

- Running history did not correlate to scan results
- The men that ran the most did not have the greatest plaque burden but were more likely to have a history of smoking, poor diet and high cholesterol values
- “You can’t just outrun your past”
- Also published a small similar study in female marathoners and found almost no plaque in their hearts

Can lifelong endurance exercise hurt the heart?

- Acute cardiovascular risks:
  - Risk for sudden cardiac death
  - Risk for acute myocardial infarction
  - Ventricular function of the heart
- Evidence of acute myocardial injury:
  - CK and CK-MB concentrations
  - Cardiac troponin concentrations
  - cTnT and cTnI concentrations
- Cardiac remodeling:
  - Dimensions of right and left ventricle
  - Dimensions of right and left atria
  - Wall thickness
- Potential cardiac maladaptations:
  - Cardiac output reduction
  - Coronary artery vasoconstriction
  - Prevalence of myocardial fibrosis
  - Risk for ventricular tachycardia
  - Risk for heart failure
- Left ventricular:
  - Systolic diameter
  - Progression of LVH

Exercise Paradox

Mature athlete

- 33% reduction in all-cause mortality
- 35% reduction in cardiovascular mortality
- 32% reduction in hypertension risk
- 42% reduction in type 2 diabetes risk
- Reduced risk of certain cancers
- Increase in healthy ageing

Positive effects of exercise on health

High lifetime volume of vigorous intensity exercise:
- Risk of AF
- Coronary artery calcification
- Myocardial fibrosis

Elevated SCD risk

~ 1:50,000
Risk Stratification for endurance athletes

- No current proven screening methods for detecting potential CV pathologic changes associated with endurance training
- Could consider post post competition blood work, echocardiography, or cardiac MRI but cost prohibitive
- Cardiac CT for CAC scoring may be useful for older athletes who have been endurance training extensively
- In patients with numerous CV risk factors consider stress testing

Conclusions

- In some individuals, long-term excessive endurance training may cause adverse structural and electrical cardiac remodeling which may provide a substrate for arrhythmia and increased CV risk but further evaluation is warranted