Arrhythmias in Endurance Athletes

Care of the Athletic Heart 2020

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Chair, ACC Sports and Exercise Leadership Council
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Faculty Disclosures

• Eugene H Chung, MD, FACC

Nothing to disclose
Summary

• Exercise and the heart
• PVCs
• Afib
Exercise is good

S Sharma et al, EHJ 2015
Exercise causes changes

Structural changes
- LVWT 10-25%
- LV and RV cavity 15%
- Bi-atrial dilatation

Functional changes
- Diastolic filling: $E' > 9 \text{ cm/s}$
- $E/E' < 6$
- $S' > 9$
- Stroke volume

Electrical changes
- Sinus bradycardia
- Sinus arrhythmia
- First degree AV block
- Voltage LVH, and RVH
- Incomplete RBBB
- TWI in V1-V4 in black athletes

Peripheral changes
- Skeletal muscle fibres
- Capillary conductance
- Oxidative capacity
- Mitochondrial enzymes
- $O_2$ Peak consumption

S Sharma et al, EHJ 2015
Atrial and Ventricular Filling Higher with Exercise

La Gerche and Claessen, JACC Imaging 2016
PVCs
60 yo male cyclist
13% PVC burden on Zio patch
Possible “structural” causes

- CAD
- Cardiomyopathy
  - HCM
  - ARVC
  - Dilated
- Infiltrative disease
- Myocarditis
- Idiopathic
### Incidence and prevalence

<table>
<thead>
<tr>
<th></th>
<th>Group A (≥2,000 PVDs and ≥1 NSVT)</th>
<th>Group B* (≥100 to &lt;2,000 PVDs)</th>
<th>Group C* (&lt;100 PVDs)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of athletes</td>
<td>71</td>
<td>153</td>
<td>131</td>
<td>&lt; 0.001†</td>
</tr>
<tr>
<td>ARVC</td>
<td>7 (10%)</td>
<td>0</td>
<td>0</td>
<td>0.0042‡</td>
</tr>
<tr>
<td>MVP</td>
<td>6 (9%)</td>
<td>5 (3%)</td>
<td>0</td>
<td>0.0003†</td>
</tr>
<tr>
<td>Myocarditis</td>
<td>4 (5.5%)</td>
<td>0</td>
<td>0</td>
<td>0.0003†</td>
</tr>
<tr>
<td>DCM</td>
<td>4 (5.5%)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>21 (30%)</td>
<td>5 (3%)</td>
<td></td>
<td>&lt; 0.001†</td>
</tr>
</tbody>
</table>

*NSVT was absent in these subgroups; †Group A versus Group B and Group A versus Group C (p < 0.05); and ‡Group A versus Group C (p < 0.05).

ARVC = arrhythmogenic right ventricular cardiomyopathy; DCM = dilated cardiomyopathy; MVP = mitral valve prolapse.

Other abbreviations as in Table 1.

A Biffi et al, JACC 2002
Mechanisms
Endurance Exercise - Structural Remodeling

La Gerche. *Eur Heart J* 2012;33:998-1006

Thijs, *Physiol Rev* 2016;96:99-125

La Gerche, *Circulation* 2014;130:992-1002
Heidbuchel et al, BJSM 2012
Workup
Ventricular arrhythmias in an athlete

Rule out underlying structural heart disease

No further studies
Follow-up

No apparent cardiomyopathy

Mildly dysfunctional RV
Symptomatic VA

Confirmed cardiomyopathy
Treat accordingly

Individualization

Idiopathic VA
(RVOT/LVOT/fascicular)

Follow-up
Detraining?
Response to exercise
Follow-up

EP Referral
Guasch and Mont, Nature Rev 2017
Treatment options

• Cardiac imaging if indicated
• AV nodal blockers (metoprolol, diltiazem)
• Antiarrhythmics (flecainide, verapamil, sotalol)
• Catheter ablation
AFib
63 yo female runner

Lead I

Lead I
Epidemiology
Estimated prevalence in gen pop

Magnani et al, Circ 2011
Atrial fibrillation in athletes and general population
A systematic review and meta-analysis

Xiangdan Li, MD, Songbiao Cui, MD, Dongchun Xuan, MD, Chunhua Xuan, MD, Dongyuan Xu, MD.

Overall OR 2.34
Risks Factors & Mechanisms
MODERATE EXERCISE Improves:
Symptoms
VO2 peak
LA and LV function
Lipids levels
QOL

Aerobic Interval Training Reduces the Burden of Atrial Fibrillation in the Short Term: A Randomized Trial
Vegard Malmo, Bjarne M. Nes, Brage H. Amundsen, Arnt-Erik Tjonna, Asbjorn Stylen, Ole Rosqvoll, Ulrik Wisloff and Jan P. Loennechen

Circulation. published online January 5, 2016;
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539
Intense Exercise

- Atrial Fibrillation
  - Atrial Stretch
  - ↑ Vagal tone
- Sinus Node disease AV block
- Ventricular arrhythmias
  - ↑ Troponin
  - Adverse cardiac remodelling
  - ? Fibrosis
- ↑ Oxidative stress
  - Shear forces
  - ? Atherosclerosis
- ? Dilated cardiomyopathy
- ? Exercise induced ARVC

S. Sharma
LA enlargement is common

A Pellicia et al, JACC 2015
a Exercise dose and U-shaped AF-risk response

Exercise and AF-related benefits:
- Blood pressure reduction
- Decreased risk of ischaemic heart disease

Potential deleterious exercise and AF-related effects:
- Myocardial fibrosis
- Atrial enlargement

b U-shape and vigorous exercise duration

Proportion of cases (%)

0 100
0 50
0 20
0 10
0

Total high-intensity exercise (h)

0 1,000
2,000
3,000
4,000

0

c U-shape and exercise intensity

Hazard ratio

0.6
1.0
1.4
1.8
2.0

CRF MET

3 6 9 12

Khan

d U-shape and exercise intensity

Hazard ratio

0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0

Physical activity level

Low
Moderate
High
Vigorous

Morseth
a Exercise dose and U-shaped AF-risk response

- Exercise and AF-related benefits
  - Blood pressure reduction
  - Decreased risk of ischaemic heart disease

- Potential deleterious exercise and AF-related effects
  - Myocardial fibrosis
  - Atrial enlargement

Newer risk factors for AF

Emerging risk factors and the dose–response relationship between physical activity and lone atrial fibrillation: a prospective case–control study

Naiara Calvo1,2, Pablo Ramos1,2, Silvia Montserrat1,2, Eduard Guasch1,2, Blanca Coll-Vinent1,2, Mònica Domenech2,3, Felipe Bisbal1,2, Sara Hevia2, Silvia Vidorreta2, Roger Borras2, Carles Falces1,2, Cristina Embid1,2, Josep Maria Montserrat1,2,4, Antonio Berruezo1,2, Antonio Coca1,2,3, Marta Sitges1,2, Josep Brugada1,2, and Lluís Mont1,2,5

1Unitat de Fibrillació Auricular, Hospital Clinic, Universitat de Barcelona, Barcelona, Catalonia, Spain; 2Institut d’Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS), Catalonia, Spain; 3Unitat d’Hipertensió i Risc Vascular, Hospital Clinic, Catalonia, Spain; and 4Unitat del Sen. Servei Pneumologia, Hospital Clinic, CIBERES Barcelona, Catalonia, Spain

Received 4 January 2015; accepted after revision 26 May 2015; online publish-ahead-of-print 1 September 2015

- LA-AP diameter
- CRP, ANP, BNP
- Obesity
- Height
- OSA
More RF, More Risk

Figure 2  Risk of AF in patients according to the presence of risk factors shown in Table 5 (OR and 95% CI).

Table 6  Risk of AF in specific exercise subgroups

<table>
<thead>
<tr>
<th>Exercise type</th>
<th>Unadjusted data</th>
<th>Adjusted for lifetime-accumulated exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(OR and 95% CI)</td>
<td>(OR and 95% CI)</td>
</tr>
<tr>
<td>Competitive sport</td>
<td>2.74 (0.88–8.47)</td>
<td>0.88 (0.23–3.43)</td>
</tr>
<tr>
<td>Team sports</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Endurance sports</td>
<td>3.4 (1.37–8.4)</td>
<td>5.68 (1.72–18.7)</td>
</tr>
<tr>
<td>Other</td>
<td>3.03 (0.9–9.7)</td>
<td>4.59 (0.5–41.1)</td>
</tr>
</tbody>
</table>
Mohanty...Natale meta analysis

- 22 studies screened, >650,000 subjects
- 9 pooled studies, >93,000 subjects
  - Significant risk of incident AF with sedentary lifestyle
- 3 studies, >149,000 women,
  - Moderate exercise reduced AF by 8.6% compared to sedentary
  - Women performing intense exercise were found to have a 28% lower risk of AF
U shaped curve revisited

Risk of AF (odds ratio)

Female
Male

Males
Greater representation in studies
Increased endurance sports participation
Most prevalent at age <50 years
More marked structural and electrical changes

Females
Lower rates of participation
Limited data in high level endurance athletes

Weight, BP, CVS mortality, Stroke, CHA2DS2-VASc

Sedentary  Low  Moderate  High
History of Endurance Training
Long-Term Incidence of Atrial Fibrillation and Stroke Among Cross-Country Skiers
Cohort Study of Endurance-Trained Male and Female Athletes

Niclas Svedberg, Johan Sundström, Stefan James, Ulf Hållmarker, Kristina Hambraeus, Kasper Andersen


- Over 200,000 skiers compared to over 520,000 nonskiers
- Female skiers had less Afib and stroke than male skiers
- Both male and female skiers had a lower risk of stroke, independent of fitness
- Male skiers who raced more and faster had more Afib
- Skiing was associated with reduction in stroke and mortality in those diagnosed with Afib
Risks Factors & Mechanisms
More PACs, More AF

N Prasitlumkum...E Chung, JECG 2018

Overall studies

<table>
<thead>
<tr>
<th>Study, years</th>
<th>RR(95% CI)</th>
<th>Weight %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archaya 2015</td>
<td>2.97 (1.84, 4.78)</td>
<td>7.38</td>
</tr>
<tr>
<td>Binici 2009</td>
<td>2.78 (1.17, 6.60)</td>
<td>4.78</td>
</tr>
<tr>
<td>Cabrera 2016</td>
<td>3.33 (1.49, 7.44)</td>
<td>5.14</td>
</tr>
<tr>
<td>Chong 2011</td>
<td>3.22 (1.89, 5.48)</td>
<td>6.98</td>
</tr>
<tr>
<td>Lin 2015</td>
<td>1.76 (1.43, 2.16)</td>
<td>9.14</td>
</tr>
<tr>
<td>Johnson 2015</td>
<td>2.75 (1.45, 5.21)</td>
<td>6.21</td>
</tr>
<tr>
<td>Murakoshi 2015</td>
<td>6.29 (5.06, 7.81)</td>
<td>9.10</td>
</tr>
<tr>
<td>Nguyen 2016</td>
<td>2.05 (1.68, 2.49)</td>
<td>9.20</td>
</tr>
<tr>
<td>Oneal 2017</td>
<td>1.92 (1.57, 2.35)</td>
<td>9.17</td>
</tr>
<tr>
<td>Perez 2009</td>
<td>2.10 (1.67, 2.65)</td>
<td>9.02</td>
</tr>
<tr>
<td>Suzuki 2013</td>
<td>7.37 (3.68, 14.77)</td>
<td>5.62</td>
</tr>
<tr>
<td>Nguyen(ARIC)2017</td>
<td>1.60 (1.29, 1.98)</td>
<td>9.11</td>
</tr>
<tr>
<td>Nguyen(CHS)2017</td>
<td>2.40 (1.88, 3.07)</td>
<td>8.95</td>
</tr>
<tr>
<td></td>
<td>2.68 (2.05, 3.49)</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Heterogeneity chi-squared = 118.87 (df = 12) p = 0.000
I-squared = 89.9%
Estimate of between-study variance Tau-squared = 0.1806
Z = 7.26 p = 0.000
LAE + PACs

AD Elliott...Prash Sanders, Clin Cardiol 2018
Rat model for fibrosis

B Benito et al, Circ 2011
Atrial fibrosis common

- 16 endurance athletes without history of arrhythmia
  - >35 yrs old
  - ≥10 yrs of competitive endurance sports ≥10 hrs/wk
- Activities included: running, cycling, rowing, and nordic skiing
- Controls were recruited during routine colonoscopy

David Peritz, MD, et al, ESC 2018; AHJ 2020 in press
RA affected first, then LA

Acute, Exercise Dose-Dependent Impairment in Atrial Performance During an Endurance Race
2D Ultrasound Speckle-Tracking Strain Analysis

Maria Sanz-de la Garza, MD, Gonzalo Grazioi, MD,1 Bart H. Bijnens, PhD,2 Sebastian I. Sarvari, MD, PhD,3–6
Eduard Guasch, MD, PhD,7 Carolina Pajuelo, MD,7 Daniel Brotons, MD, PhD,7 Enric Subirats, MD, PhD,7
Ramon Brugada, MD, PhD,7 Emma Roca, PhD,7 Marta Sitges, MD, PhD8

European Heart Journal - Cardiovascular Imaging (2018) 19, 145–153
doi:10.1093/ehjci/jjx225

Atrial function is altered in lone paroxysmal atrial fibrillation in male endurance veteran athletes

Arnaud Hubert1,2,3, Vincent Galand1,2,3, Erwan Donal1,2,2, Dominique Pavin1,2,3, Elena Galli1,2,3, Raphaël P. Martin1,2,3, Christophe Leclercq1,2,3, François Carré2,3,4, and Frédéric Schnell2,3,4*

1Department of Cardiology, Pitié-Salpêtrière Hospital, 2 rue Henri Le Guichoux, Rennes 35033, France; 2CTI, Université Rennes 1, Campus de Beaulieu, Bâtiment 22, 353 Avenue du Général Leclerc, Rennes 35042, France; 3INSERM U1079, Université Rennes 1, Campus de Beaulieu, Bâtiment 22, 353 Avenue du Général Leclerc, Rennes 35042, France; and 4Department of Sport Medicine, Pitié-Salpêtrière Hospital, 2 rue Henri Le Guichoux, Rennes 35033, France

Received 26 May 2017; revised decision 30 August 2017; accepted 31 August 2017; online publish-ahead-of-print 23 October 2017
Prospective data...

Circulation: Arrhythmia and Electrophysiology

ORIGINAL ARTICLE

Does High-Intensity Endurance Training Increase the Risk of Atrial Fibrillation?
A Longitudinal Study of Left Atrial Structure and Function

BACKGROUND: Exercise mitigates many cardiovascular risk factors associated with atrial fibrillation. Endurance training has been associated with atrial structural changes which can increase the risk for atrial fibrillation. The dose of exercise training required for these changes is uncertain. We sought to evaluate the impact of exercise on left atrial (LA) mechanical and electrical function in healthy, sedentary, middle-aged adults.

METHODS: Sixty-one adults (52±5 years) were randomized to either 10 months of high-intensity exercise training or yoga. At baseline and post-training, all participants underwent maximal exercise stress testing to assess cardiorespiratory fitness, P-wave signal-averaged electrocardiography for filtered P-wave duration and atrial late potentials (root mean square voltage of the last 20 ms), and echocardiography for...
Left Atrial Electromechanical Remodeling Following 2 Years of High-Intensity Exercise Training in Sedentary Middle-Aged Adults

BACKGROUND: Moderate intensity exercise is associated with a decreased incidence of atrial fibrillation. However, extensive training in competitive athletes is associated with an increased atrial fibrillation risk. We evaluated the effects of 24 months of high intensity exercise training on left atrial (LA) mechanical and electric remodeling in sedentary, healthy middle-aged adults.

METHODS: Sixty-one participants (53±5 years) were randomized to 10 months of exercise training followed by 14 months of maintenance exercise or stretching/balance control. Fourteen Masters athletes were added for comparison. Left ventricular (LV) and LA volumes underwent 3D echocardiographic assessment, and signal-averaged electrocardiographs for filtered P-wave duration and atrial late potentials were completed at 0, 10, and 24 months. Extended ambulatory monitoring was performed at 0 and 24 months. Within and between group differences from baseline were compared using mixed-effects model repeated-measures analysis.
Figure 1. The effect of exercise training on left atrial volume.

Figure 2. The effect of exercise training on left atrial ejection fraction.
Figure 3. The effect of exercise training on left ventricular end diastolic volume.

Figure 4. Ratio of left atrial to left ventricular end diastolic volume.
**Arrhythmias and Adaptations of the Cardiac Conduction System in Former National Football League Players**


**Table 4. Uni- and Multivariable Regression of AF Predictors in the NFL Group (Table view)**

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Univariable analysis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>2.8</td>
<td>1.7–4.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>1.4</td>
<td>1.0–2.0</td>
<td>0.05</td>
</tr>
<tr>
<td>Black race</td>
<td>0.2</td>
<td>0.1–0.5</td>
<td>0.004</td>
</tr>
<tr>
<td>Lineman</td>
<td>1.5</td>
<td>0.6–4.0</td>
<td>0.39</td>
</tr>
<tr>
<td>Years played in NFL</td>
<td>1.0</td>
<td>0.6–1.5</td>
<td>0.88</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>1.1</td>
<td>0.7</td>
<td>0.43</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.2</td>
<td>0.5–2.9</td>
<td>0.65</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>0.7</td>
<td>0.2–2.9</td>
<td>0.58</td>
</tr>
<tr>
<td>LVMI, g/m²</td>
<td>1.4</td>
<td>1.0–2.0</td>
<td>0.07</td>
</tr>
<tr>
<td>LAVI, mL/m²</td>
<td>2.8</td>
<td>2.0–4.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LVEF, %</td>
<td>0.7</td>
<td>0.5–0.9</td>
<td>0.01</td>
</tr>
<tr>
<td>E/e’</td>
<td>1.8</td>
<td>1.3–2.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Multivariable analysis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAVI, mL/m²</td>
<td>3.1</td>
<td>2.1–4.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>1.1</td>
<td>1.0–1.3</td>
<td>0.01</td>
</tr>
<tr>
<td>Black race</td>
<td>0.1</td>
<td>0.02–0.4</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Management
Lifestyle modification: REVERSE-AF

ME Middeldorp...P Sanders, EP Europace 2018
Treatment options

• Anticoagulants (CHA$_2$DS$_2$VASC score)
• AV nodal blockers (metoprolol\*, diltiazem)
• Antiarrhythmics (flecainide\*, propafenone, dronedarone; sotalol, dofetilide, amiodarone)
• Catheter ablation
NEJM.org, Fire and Ice trial
Athletes and AF RFA

18/20 in SR, but 2.3 proc per pt

Furlanello et al, JCE 2008

Calvo et al, Europace 2010
Atrial Fibrillation Catheter Ablation Increases the Left Atrial Pressure

**BACKGROUND:** We previously reported that a high left atrial (LA) pressure is associated with LA stiffness and poor rhythm outcomes after de novo catheter ablation of atrial fibrillation. Herein, we investigated whether radiofrequency catheter ablation generally changes the LA pressure among patients undergoing repeat procedures.

**METHODS:** Among 1848 patients who underwent atrial fibrillation catheter ablation, we measured the LA pressure during sinus rhythm in 1687 patients before the de novo ablation (59±11 years, 72.4% men, 77.8% paroxysmal atrial fibrillation) and in 142 with second procedures.
US and Europe: IIa indication for RFA

1. Athletes with AF should undergo a workup that includes thyroid function, tests, queries for drug use, ECG, and echocardiogram (Class I; Level of Evidence B).
2. Athletes with low-risk AF that is well tolerated and self-terminating may participate in all competitive sports without therapy (Class I; Level of Evidence C).
3. In athletes with AF, when antithrombotic therapy, other than aspirin, is indicated, it is reasonable to consider the bleeding risk in the context of the specific sport before clearance (Class IIa; Level of Evidence C).
4. Catheter ablation for AF could obviate the need for rate control or antiarrhythmic drugs and should be considered (Class IIa; Level of Evidence B).

2015 Eligibility and Disqualification document

2016 ESC Afiib guidelines
63 yo female runner

- Single lead (I) ECG recording of Afib
- $\text{CHA}_2\text{DS}_2\text{VASc}$ score = 1 for HTN, so we jointly chose not to start OAC
- 14 day ECG patch monitor showed <3% overall Afib burden, no episode longer than 12 hours
- We discussed pill-in-the-pocket approach, patient deferred
- Role of OAC added as in-the-pocket in such cases still up for debate
60 yo male runner, skier, cyclist, canoeist

Atrial Fibrillation

▼ Fastest AF (HR Range 71-256 bpm, Avg 149 bpm)

AF Burden < 1%
Longest Duration 1 h 39 m
HR Range 71-256 bpm
Avg 149 bpm
Cryoballoon Ablation Helps Elite Athlete Stay Competitive

A minimally invasive procedure treated a dedicated athlete’s atrial fibrillation — and allowed him to enjoy multiple athletic pursuits again.
“I'm doing very well. I had a full summer of biking and canoeing, and just wrapped up a very good ski season. (See attached picture.)”

3/2019, 6/2020
Summary

- Exercise and the heart
- PVCs
- Afib
- {Wearables- selection and application}
- {Implantable devices- selection and programming}