

Pravá komora u sportovců

Aleš Linhart

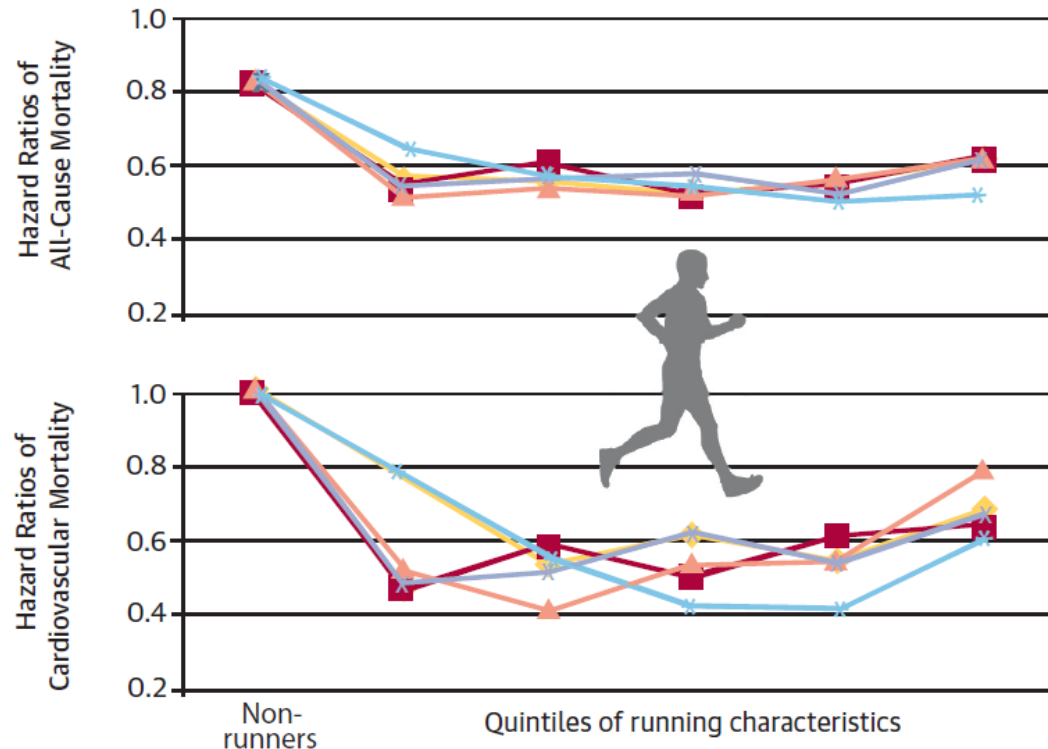
**II. interní klinika
kardiologie a angiologie**

**Komplexní
kardiovaskulární centrum**

**VFN a 1. LF UK
Praha**



Rychlost, frekvence a vzdálenost běhu a mortalita



	Time (min/wk)	0	<51	51-80	81-119	120-175	≥176
	Distance (miles/wk)	0	<6	6-8	9-12	13-19	≥20
	Frequency (times/wk)	0	1-2	3	4	5	≥6
	Total amount (MET-min/wk)	0	<506	506-812	813-1199	1200-1839	≥1840
	Speed (mph)	0	<6.0	6.0-6.6	6.7-7.0	7.1-7.5	≥7.6

Intenzita fyzické aktivity a morbidita u žen

National Health Service (NHS) breast cancer screening

1,1 milionu žen

Bez KV onemocnění

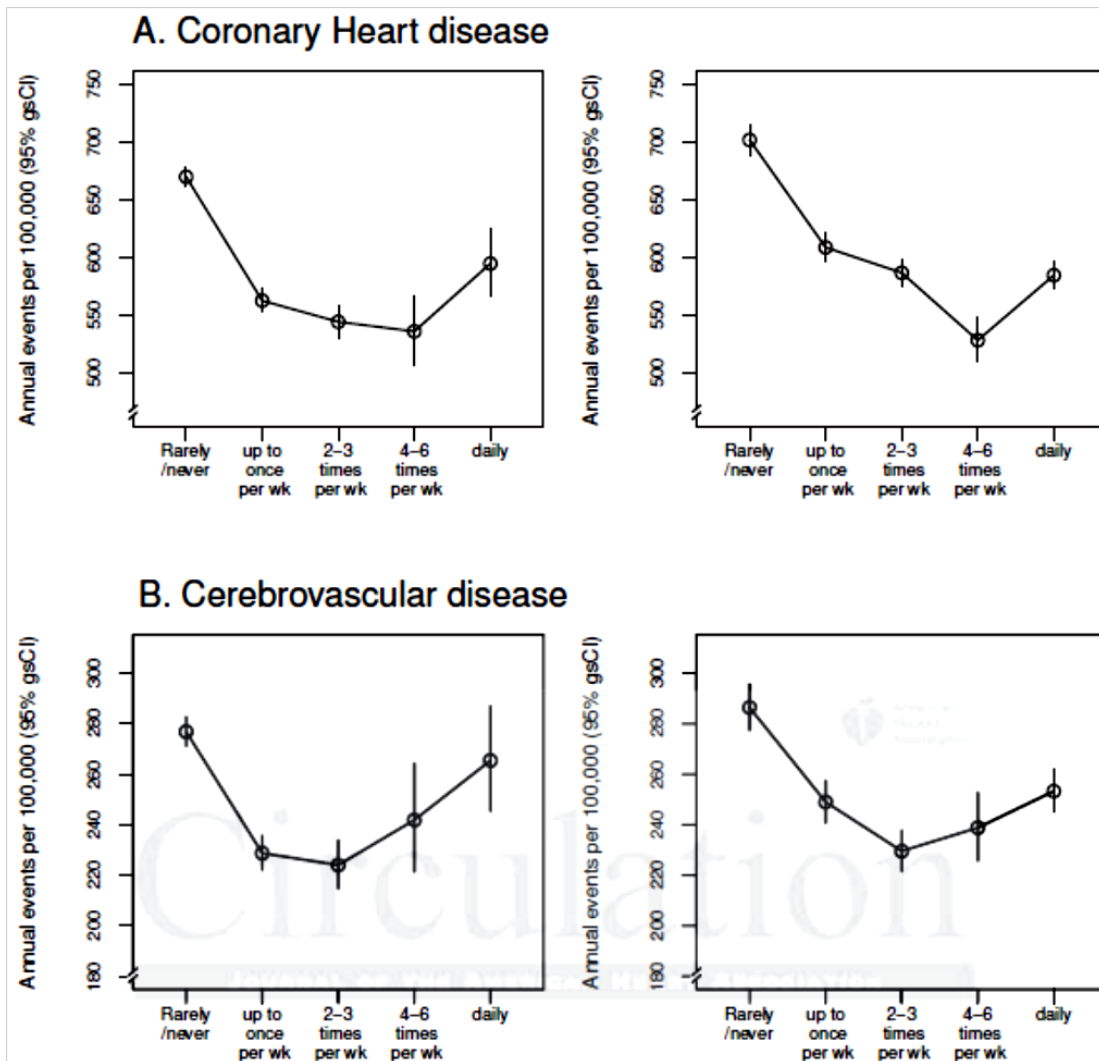
Sledování 9 let

49 113 koronární příhoda

17 822 CMP

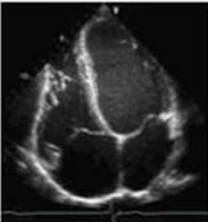
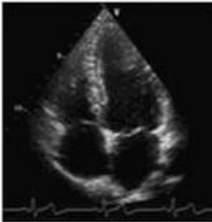
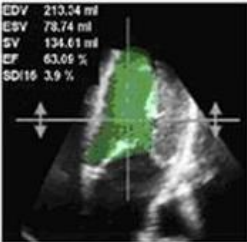

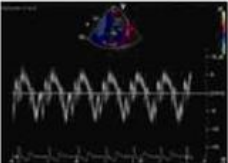
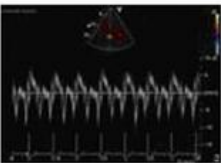
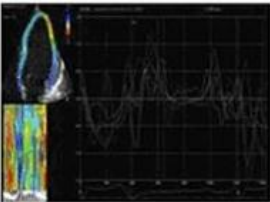
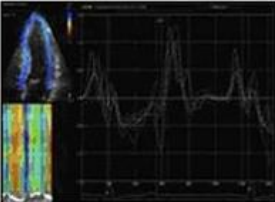

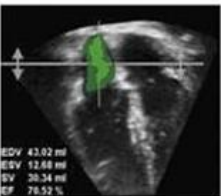
Intenzivní aktivita

Jakákoli aktivita



ATLETICKÉ SRDCE?

Očekávané změny levé komory

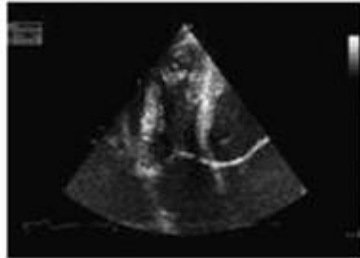
	Athlete	Non-Athlete
Left Ventricular Function		
Morphology	 <p>IVSd 8 - 16* mm < 13 mm LVIDd 49 - 73 mm < 65 mm LVM 113 - 618* g < 400 g</p>	 <p>IVSd 6 - 10 mm LVIDd 42 - 59 mm LVM 88 - 224 g</p>
Volumes/ EF(%)	 <p>EDV 210.04 ml ESV 79.74 ml SV 134.61 ml EF 63.06 % SDI16 3.9 %</p> <p>LVEDV 130 - 260 ml < 240 ml EF 41 - 77% > 48%</p>	 <p>EDV 92.36 ml ESV 38.43 ml SV 54.83 ml EF 59.38 % SDI16 5.9 %</p> <p>LVEDV 67 - 155 ml EF >55%</p>
Tissue Doppler	 <p>S_m 6.5 - 14 cm/s E_m 7.5 - 16 cm/s</p>	 <p>S_m > 6 cm/s † E_m > 8 cm/s</p>
Strain/ Strain rate	 <p>Not clearly different from non-athletes</p>	 <p>Normal values not established</p>
LA size	 <p>EDV 72.09 ml ESV 33.11 ml SV 38.99 ml EF 54.08 %</p> <p>22 - 55 mm (diameter)</p>	 <p>EDV 43.02 ml ESV 12.68 ml SV 30.34 ml EF 78.52 %</p> <p>30 - 40 mm (diameter)</p>

Co lze očekávat u PK?

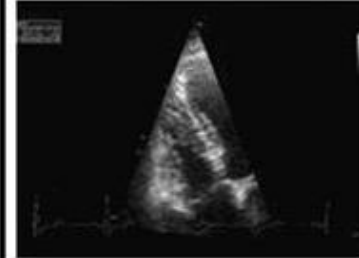
Atleti

Ne-atleti

RVFAC

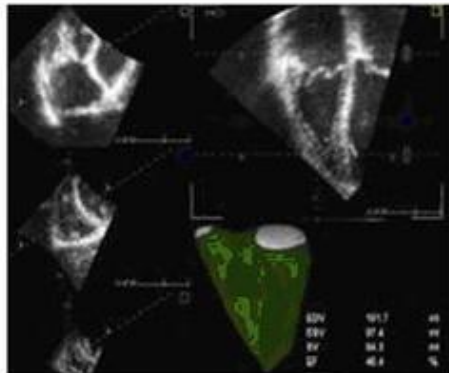


26 - 60%



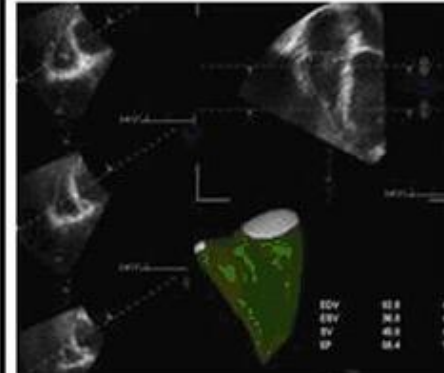
32 - 60%

Volumes/
EF (%)



RVEDV
130 - 260 ml

RVEF
>45%

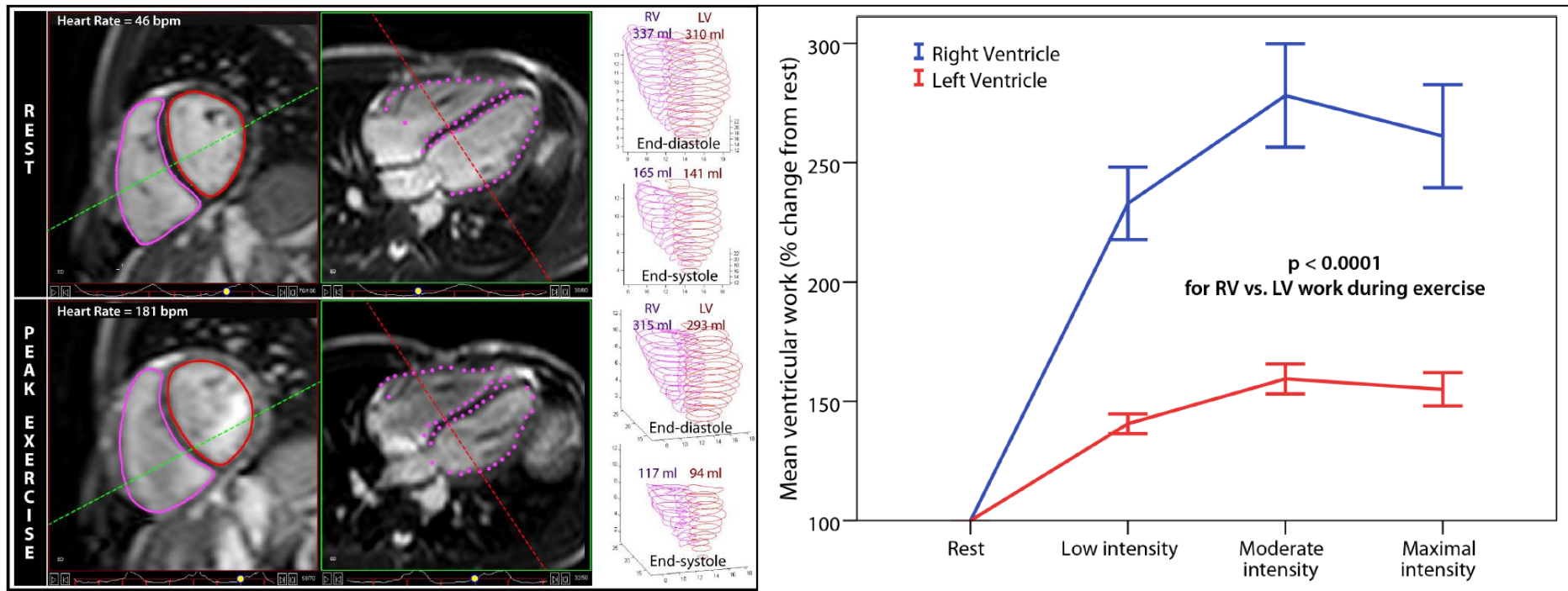


RVEDV
60 - 150 ml

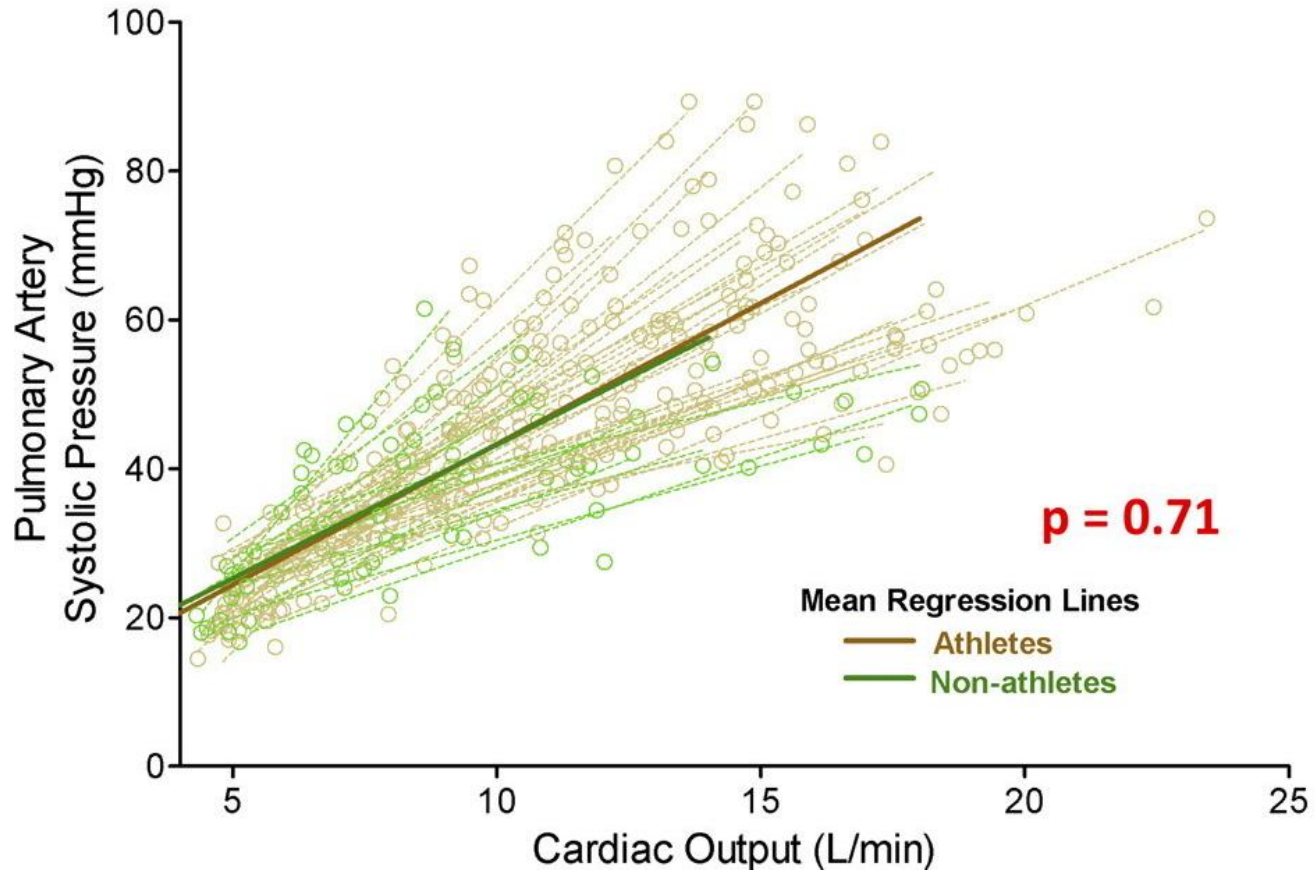
RVEF
>50%†

Zátěž PK je větší než LK

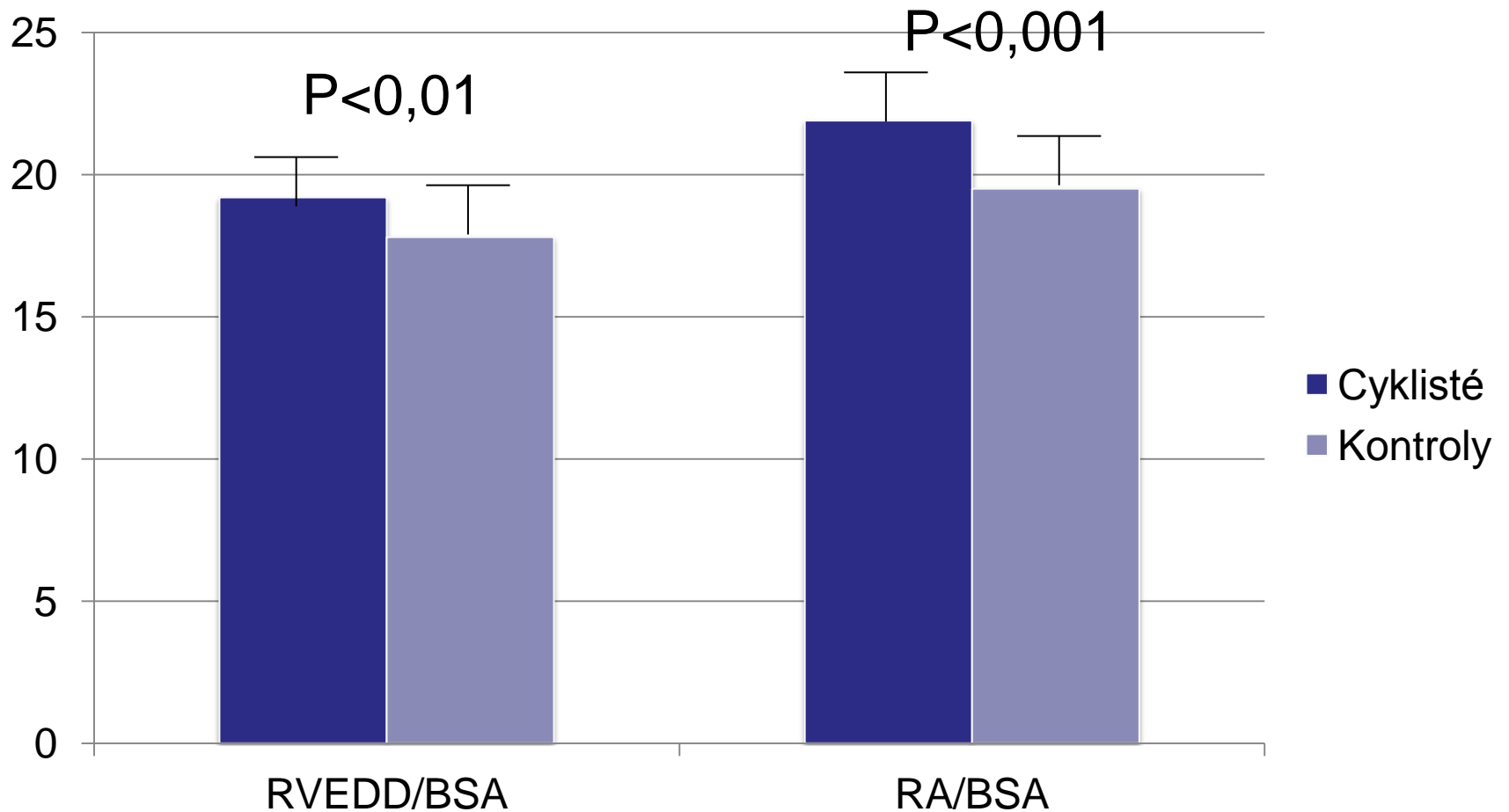
- 10 atletů vs. 6 kontrol
- Zátěžová MRI + invazivně měřené tlaky (MPAP a mBP)
- Výpočet práce PK = $SV \times mPAP$; LK = $SV \times mBP$



Zvýšení PAPS během zátěže (echokardiografická studie s kontrastem)



Dilatace pravé komory i síně je prokazatelná i u amatérských cyklistů



3D echokardiografie potvrzuje dilataci PK u vytrvalostních atletů

Variable	Controls	STAs	ETAs
RV wall thickness (mm)	3.64 ± 1.2 (2.1–4.6)	3.7 ± 1.1 (2.5–5)	3.6 ± 0.9 (2.8–5.4)
RV basal diameter (mm)	32.5 ± 4.2 (26–39)	33.3 ± 5.3 (27–40)	38.7 ± 5.4* (33–45)
RV middle ventricle diameter (mm)	27.6 ± 4.4 (22–34)	27.5 ± 6.4 (22–36)	33.5 ± 5.4* (28–40)
RV base-to-apex diameter (mm)	76.6 ± 6.8 (68–84)	77.8 ± 6.3 (68–86)	80.5 ± 5.8 [†] (73–87)
RV 3D end-diastolic volume (mL)	126.3 ± 23.1 (110–155)	140.3 ± 25.1 (120–165)	171 ± 33.4 (138–210)*
RV 3D end-systolic volume (mL)	56 ± 18.3 (36–78)	62 ± 23.4 (38–87)	66 ± 23.1 (40–93)
Indexed RV 3D end-diastolic volume [mL/(m ²) ^{0.43}] [‡]	73.5 ± 13.1 (59–86)	77.8 ± 11.3 (64–90)	94.4 ± 20.4 (76–115) [§]
Indexed RV 3D end-systolic volume [mL/(m ²) ^{0.32}] [‡]	33.4 ± 10.3 (19–44)	35.8 ± 12.4 (21–47)	37 ± 14.1 (23–51)
RV sphericity index	0.34 ± 0.08 (0.22–0.43)	0.37 ± 0.07 (0.24–0.44)	0.42 ± 0.07 [†] (0.33–0.5)
TAPSE (mm)	22.7 ± 2.2 (20–25)	22.4 ± 2.4 (20–25)	23.5 ± 2.8 (20–26)
RV area change (%)	49.6 ± 2.3 (46–51)	48.7 ± 3.3 (47–52)	49.5 ± 3.67 (47–53)
RV 3D ejection fraction (%)	58.7 ± 9.5 (46–66)	59.8 ± 8.5 (47–68)	63.5 ± 9.4 (48–68)

TAPSE, Tricuspid annular plane systolic excursion.

Data presented as mean ± SD, with ranges in parentheses.

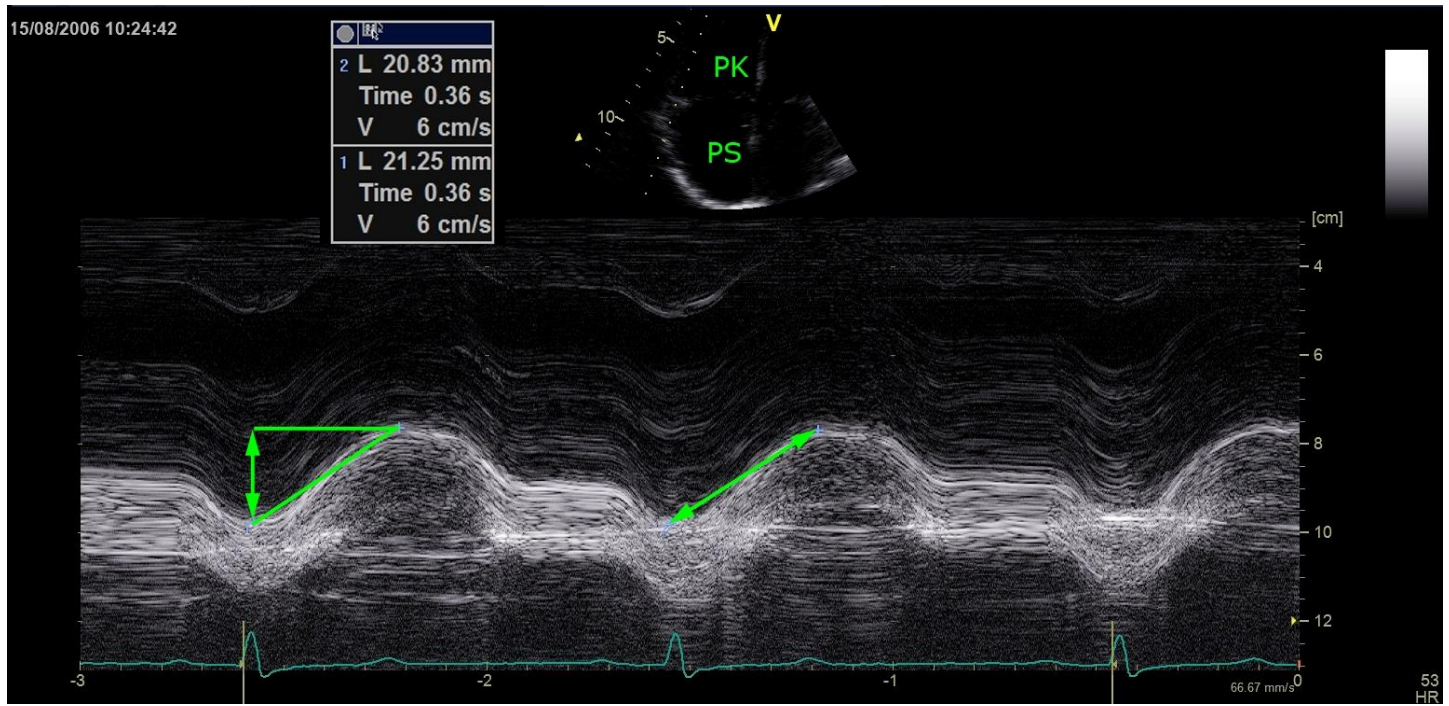
**P* < .001 ETAs vs STAs and controls.

[†]*P* < .01 ETAs vs STAs and controls.

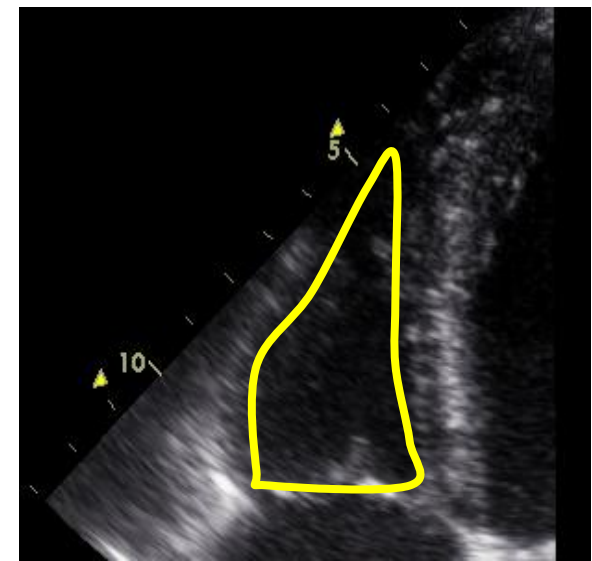
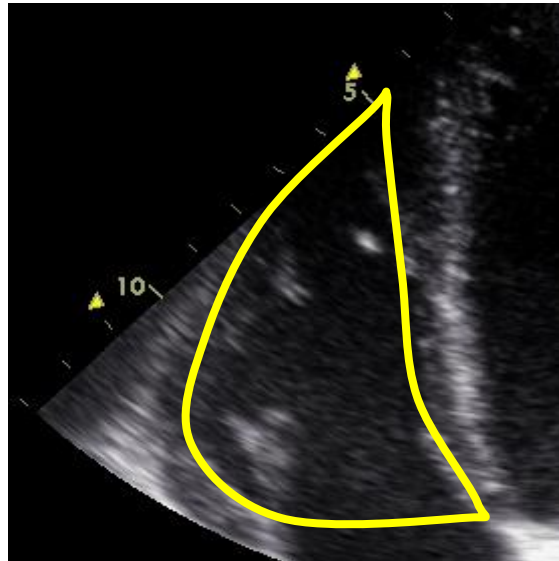
[‡]Allometric scaling (size independent).

TAPSE a RV EF klidově normální !

TAPSE

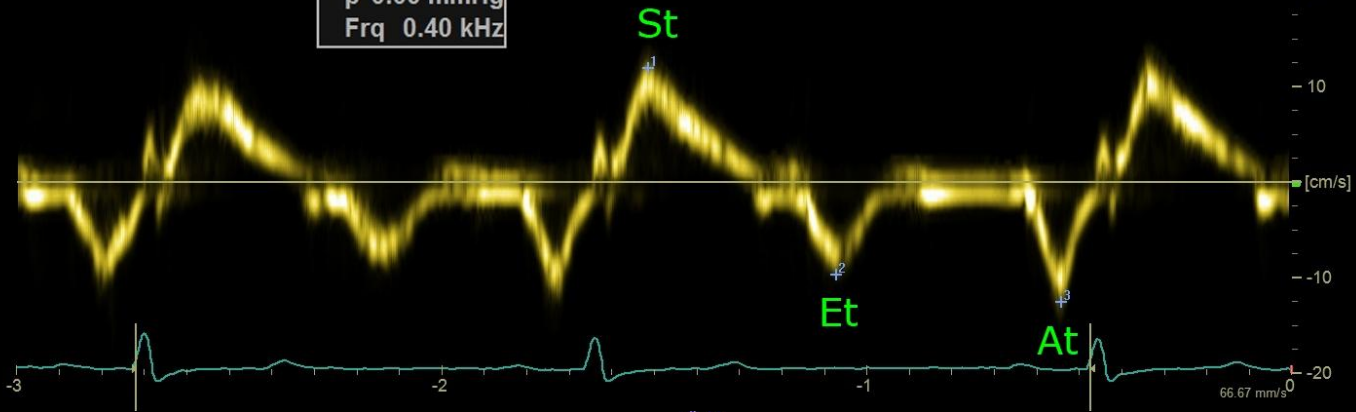
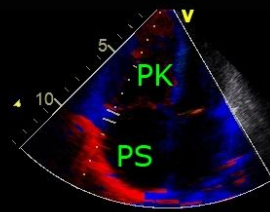


FAC

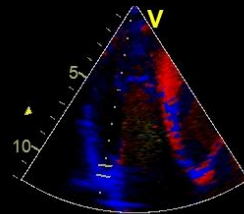


$$\text{FAC} = (\text{EDA-ESA})/\text{EDA} \times 100$$

3 v	0.12 m/s
p	0.06 mmHg
Frq	0.41 kHz
2 v	0.10 m/s
p	0.04 mmHg
Frq	0.32 kHz
1 v	0.12 m/s
p	0.06 mmHg
Frq	0.40 kHz

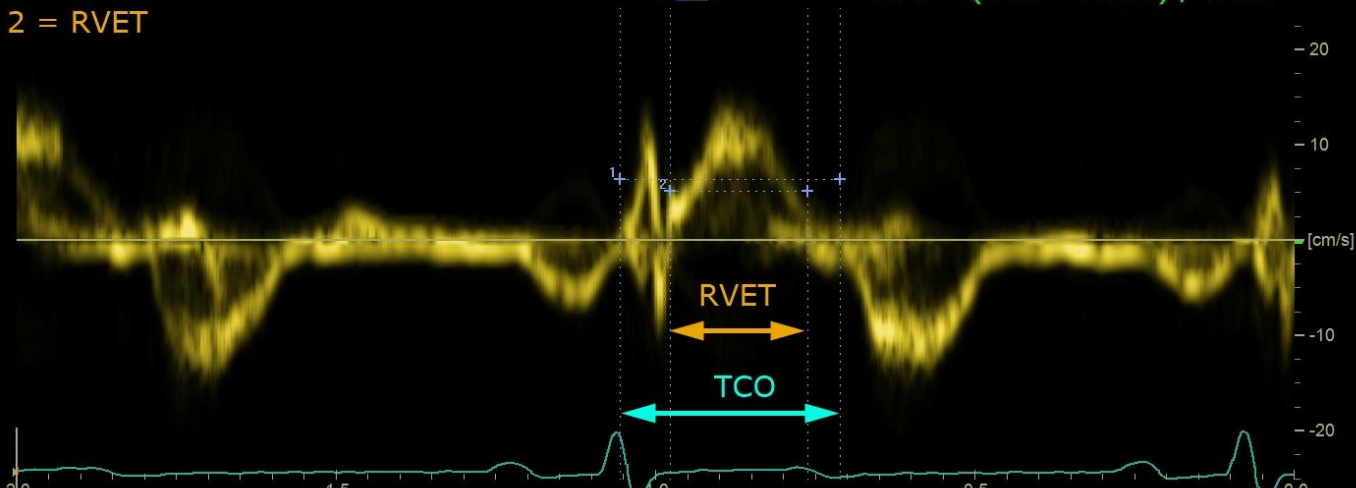


2 Time	215 ms
1 Time	344 ms

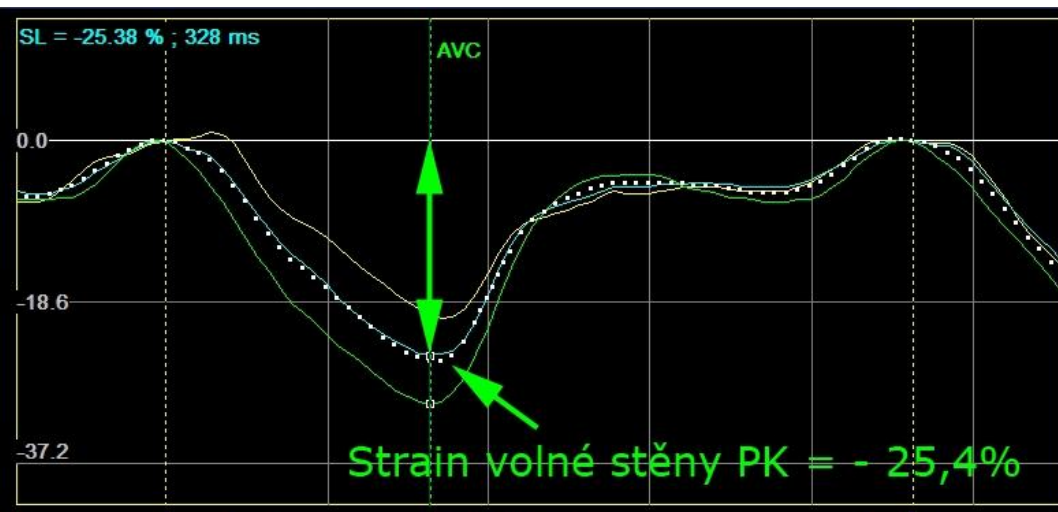
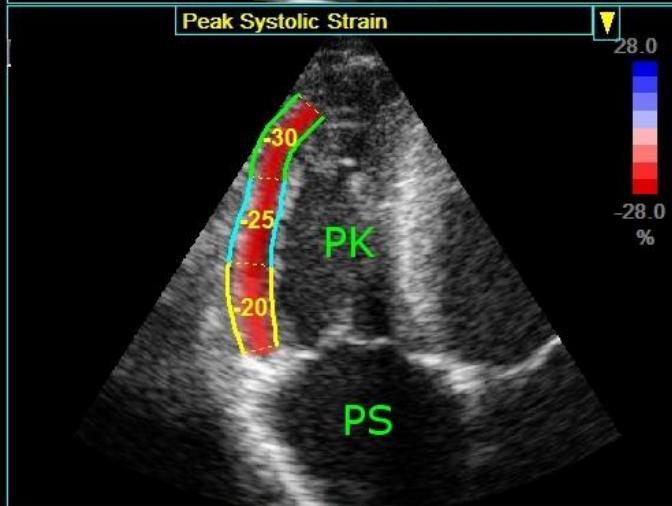
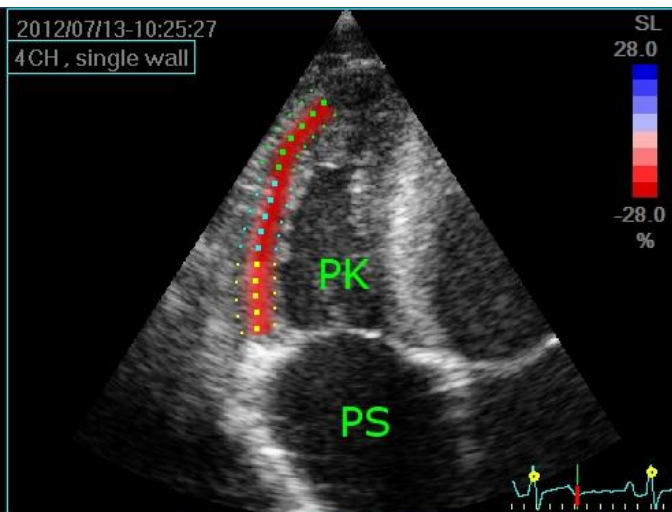


1 = IVCT + RVET + IVRT = TCO
 2 = RVET

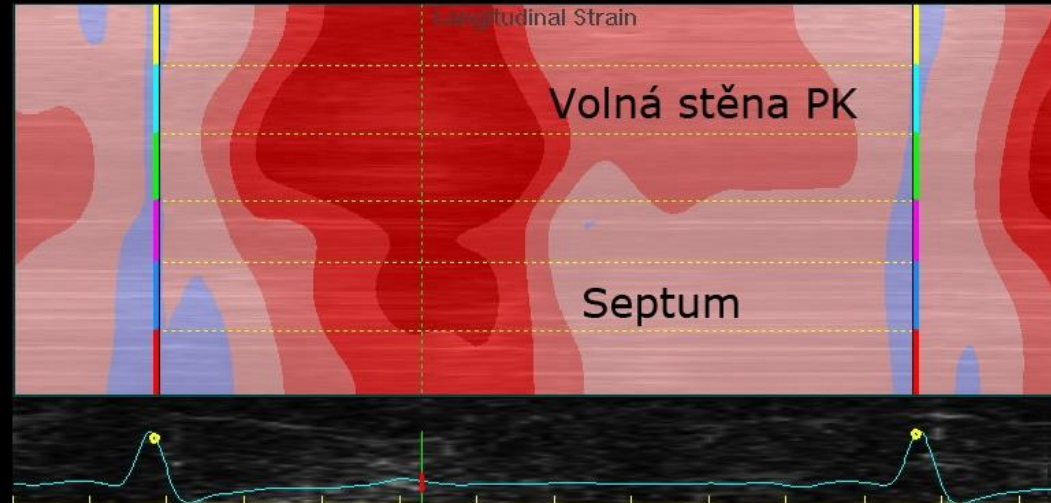
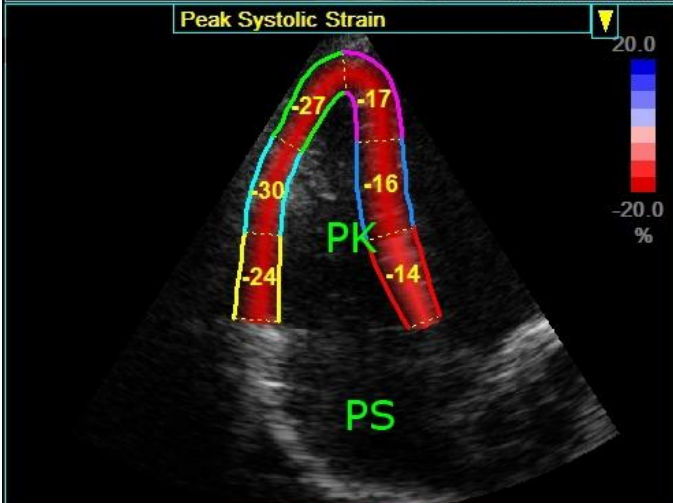
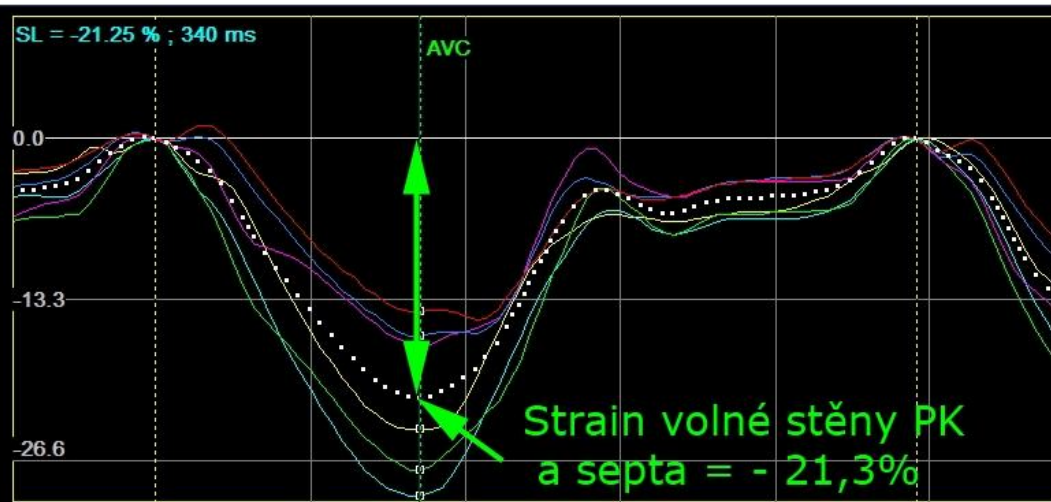
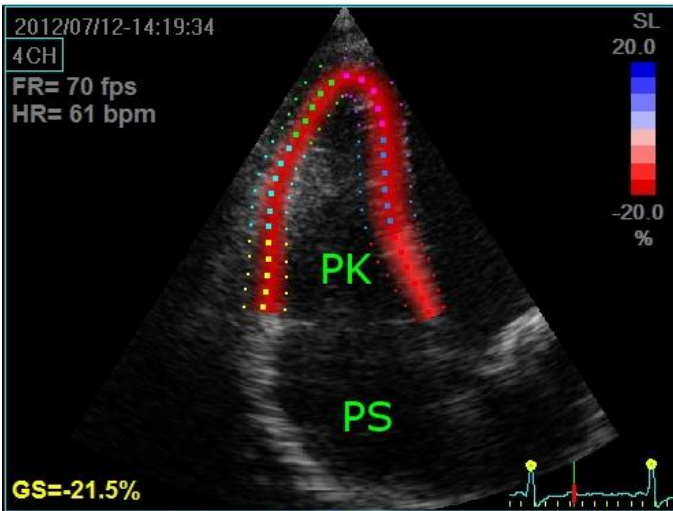
$$MPI = (TCO - RVET) / RVET$$



Speckle tracking – volná stěna PK



Speckle tracking – volná stěna PK

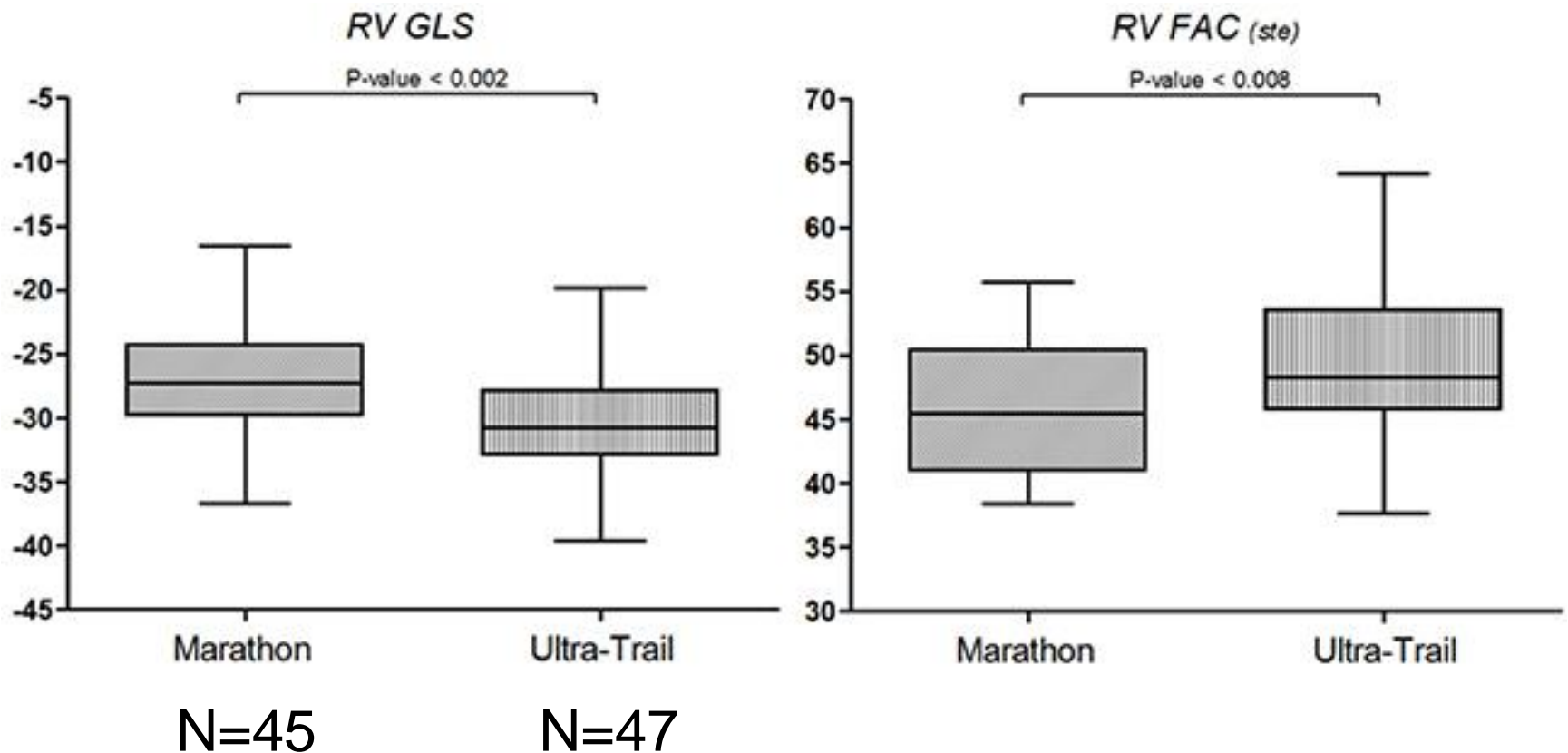


Klidová funkce PK by měla být normální nebo supranormální – speckle tracking a TDI

	HKMP	Atleti	
RV fractional area change (%)	33.2 ± 2.4	34.2 ± 1.4	NS
TAPSE (cm)	1.87 ± 0.33	1.91 ± 0.35	NS
RV Tei index	0.47 ± 0.04	0.39 ± 0.06	<0.01
Tissue Doppler RV S _m peak velocity (m/s)	9.4 ± 2.1	12.3 ± 3.1	<0.01
RV lateral wall mean 2DSE (%)	14.3 ± 4.1	22.4 ± 3.8	<0.001
RV septal wall mean 2DSE (%)	14.2 ± 4.5	21.4 ± 3.4	<0.001
RV GLS (%)	14.2 ± 4.4	21.7 ± 3.6	<0.001

Pravá komora u maratonců a ultramaratonců

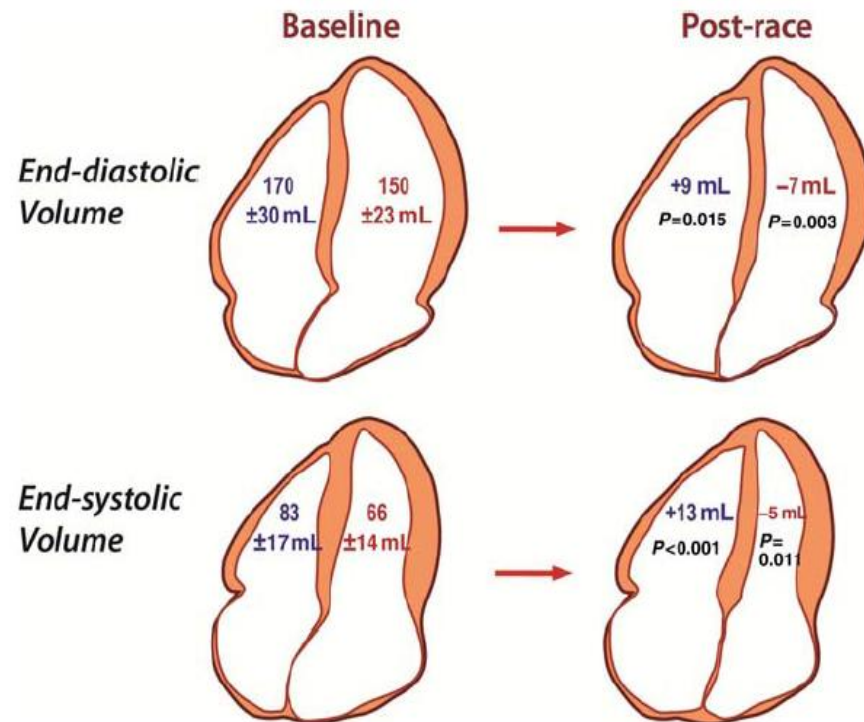
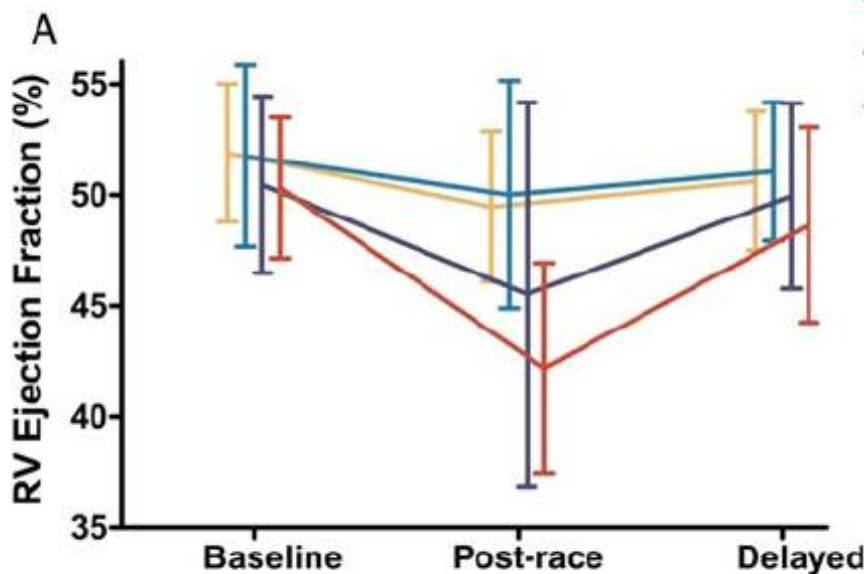
Ultramaratonci měli větší PK, TAPSE, VCI, TRV,



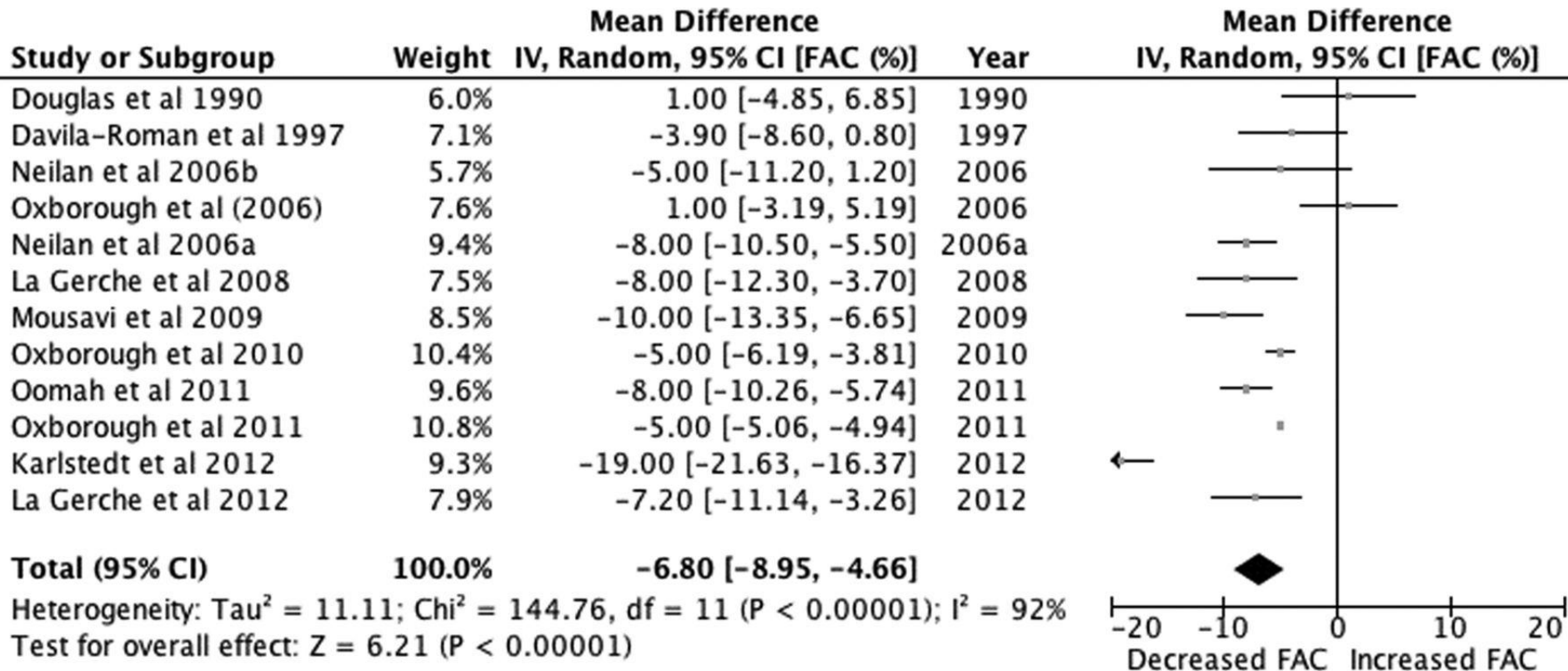
Změny PK v souvislosti s výraznou vytrvalostní fyzickou aktivitou

40 atletů po dlouhém vytrvalostním závodě 3-11 hodin

- Marathon (3h)
- Endurance triathlon (5.5h)
- Alpine cycling (8h)
- Ultra triathlon (11h)

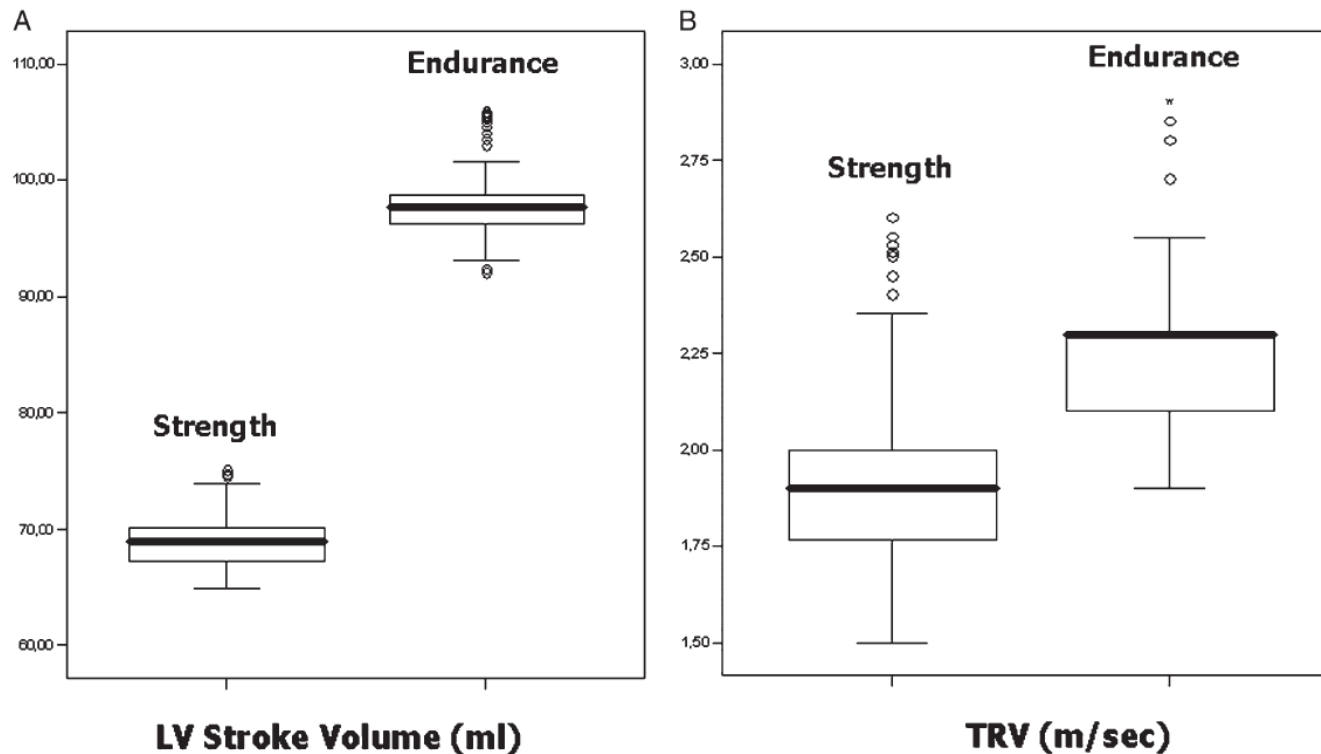


Pokles funkce PK hodnocené FAC po vytrvalostní zátěži - metaanalýza



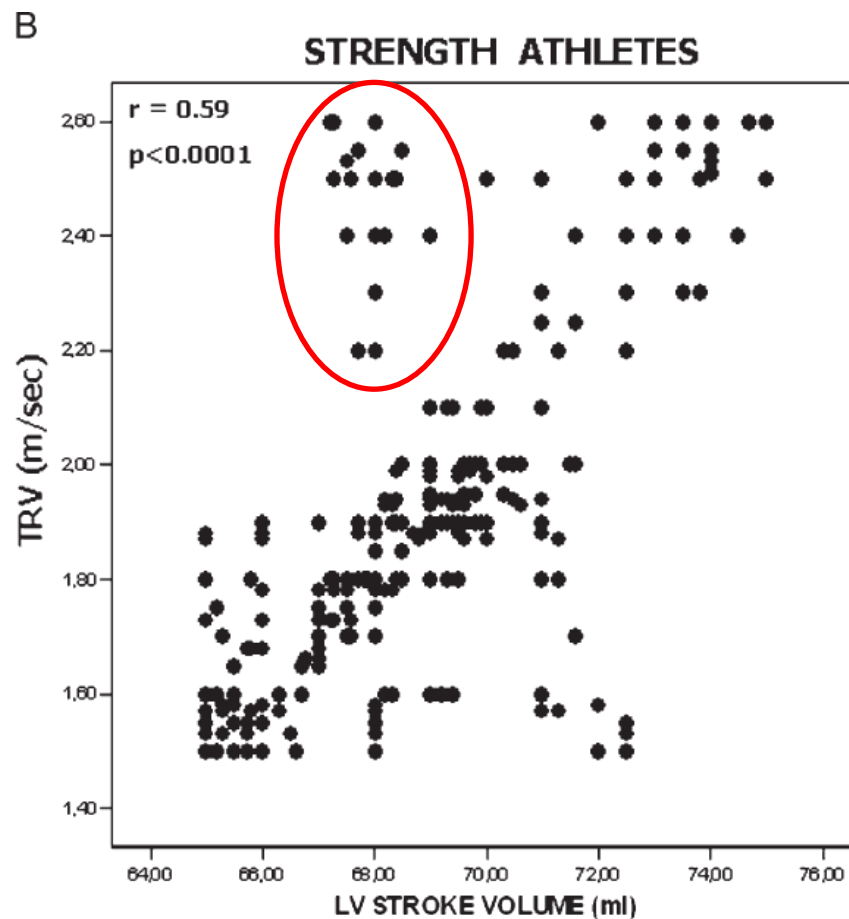
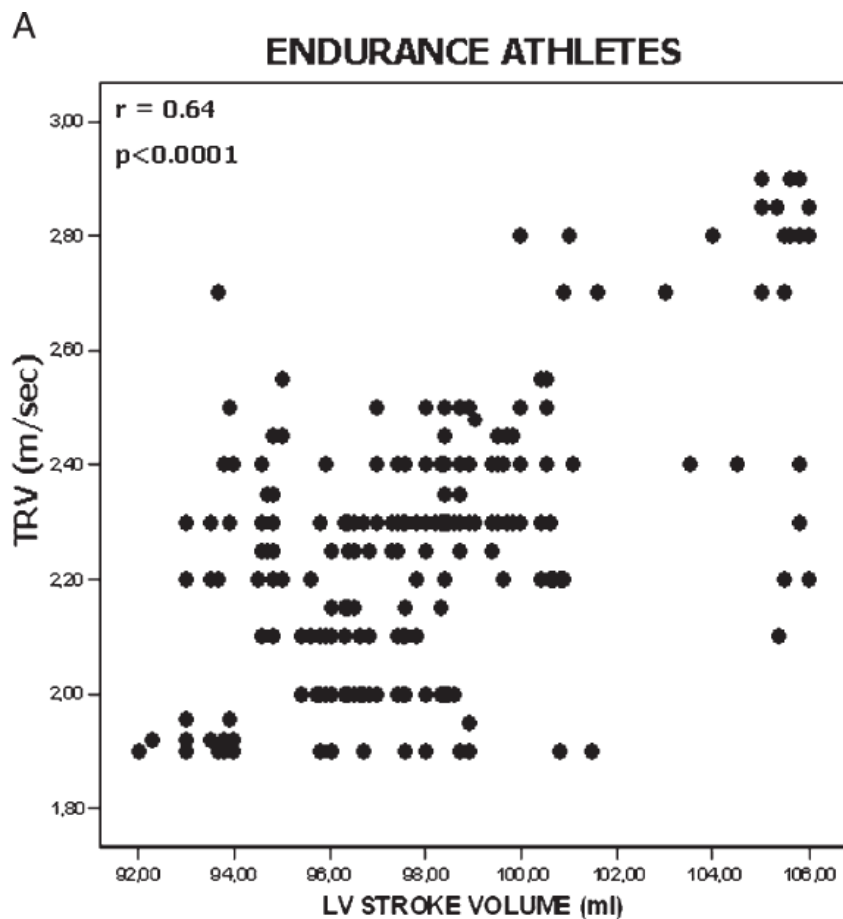
Klidové hodnoty PASP odhadnuté echokardiograficky

Variable	Control Subjects	Strength	Endurance
TRV, m/s	1.8 ± 0.7 (1.3-2.4)	1.9 ± 0.5 (1.5-2.6)	2.3 ± 0.5^a (1.9-2.9)
PASP, mm Hg	17.6 ± 4.6 (14-33)	19.4 ± 8.1 (14-36)	26.1 ± 6.6^a (19-39)
TRV/RVOTVI, m/s/cm	0.13 ± 0.04 (0.07-0.15)	0.12 ± 0.04 (0.07-0.16)	0.13 ± 0.05 (0.09-0.18)



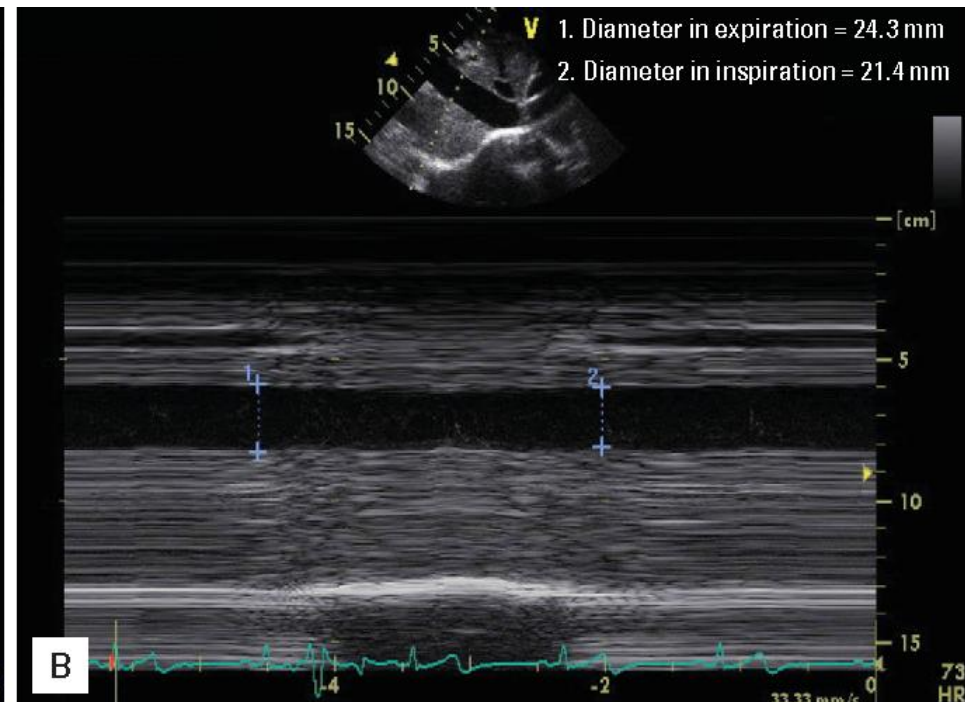
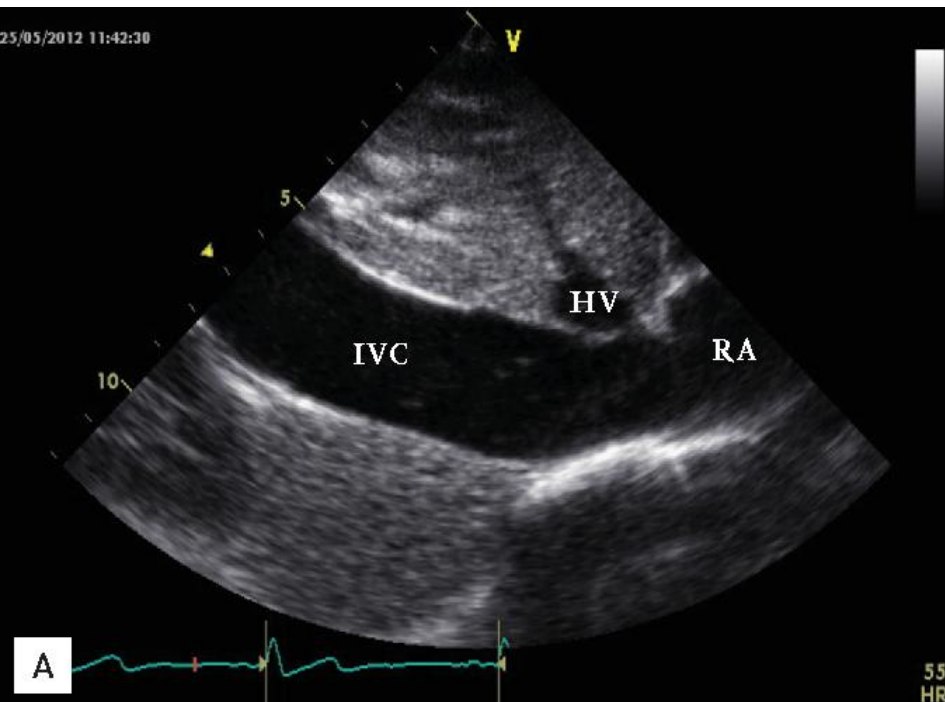
Vyšší hodnoty PASP u atletů s větším tepovým objemem

	Kontroly	Siloví atleti	Vytrvalostní atleti
LV SV (ml)	63.4±5.9	69.4±3.3	98.4±6.2

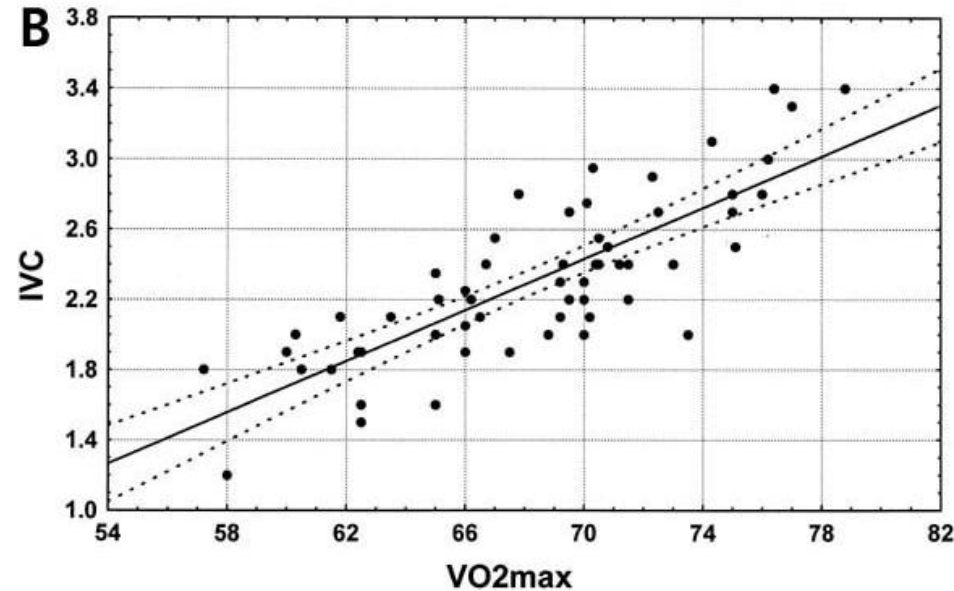
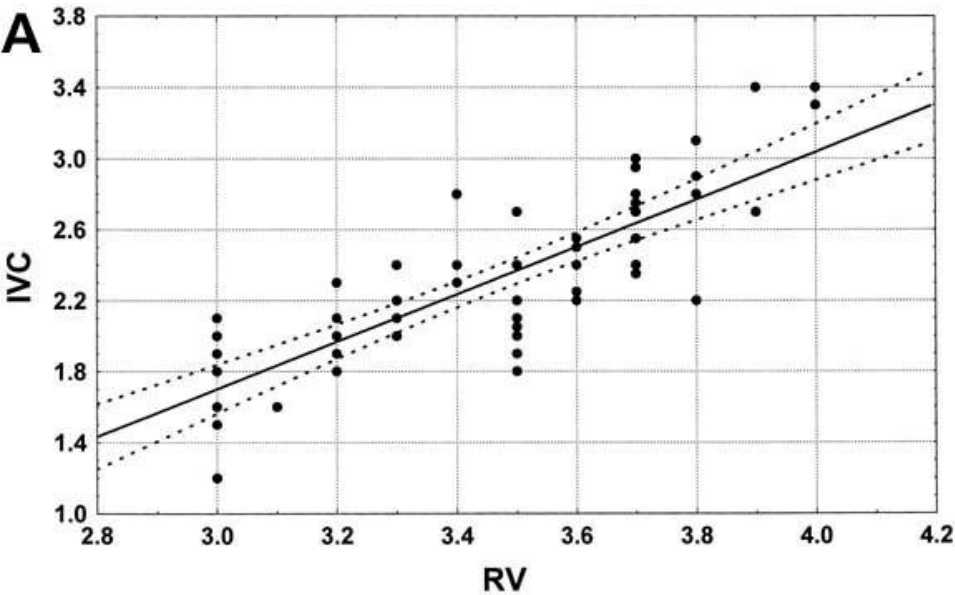


Dilatace VCI u atletů

	Atleti	Kontroly	
IVC (cm)	$2,31 \pm 0,46$	$1,14 \pm 0,13$	$<0,001$
Kolapsibilita (%)	$58 \pm 6,4$	$70,2 \pm 4,9$	$<0,001$



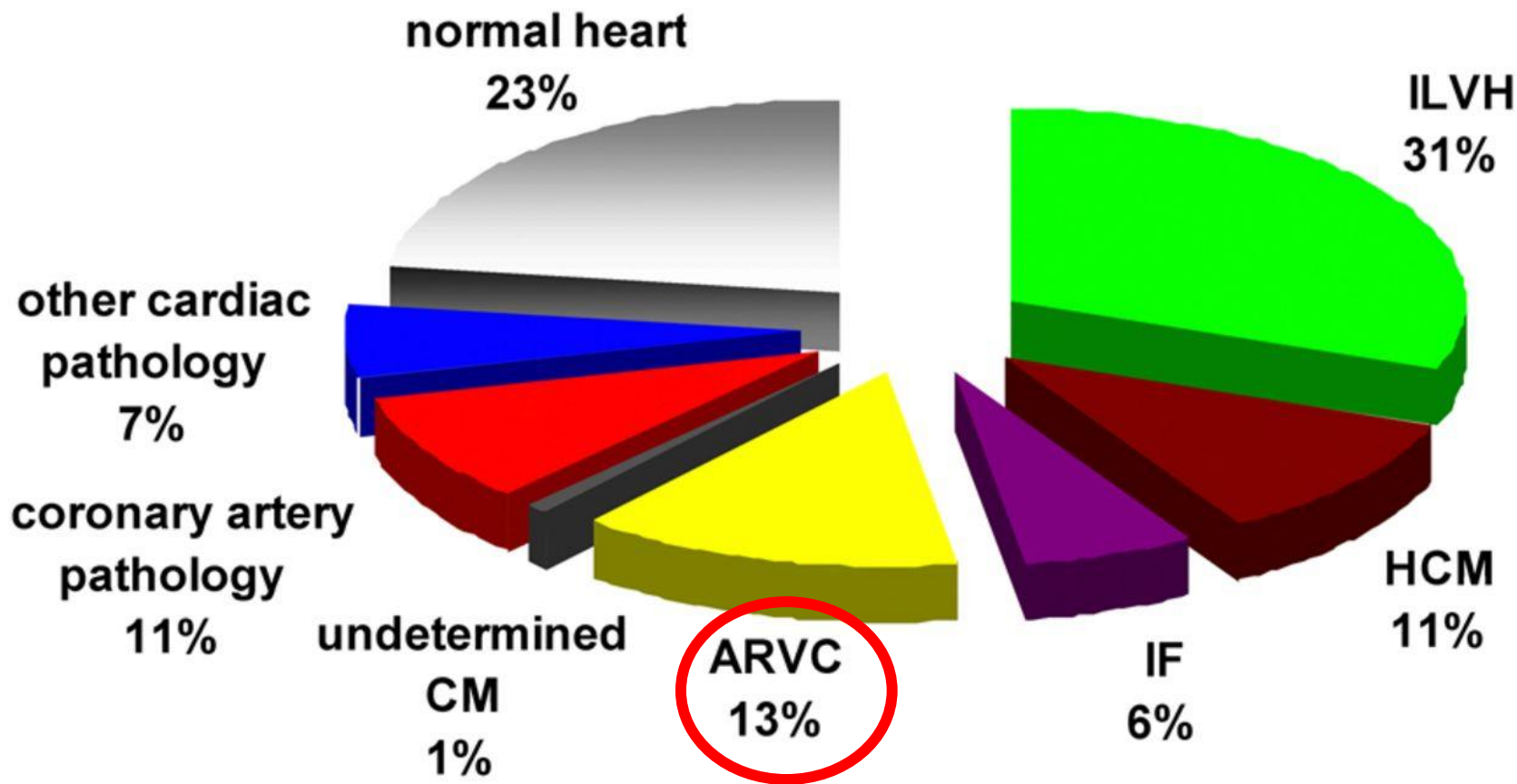
Dilatace VCI koreluje s velikostí PK a stupněm trénovanosti



Co lze očekávat?

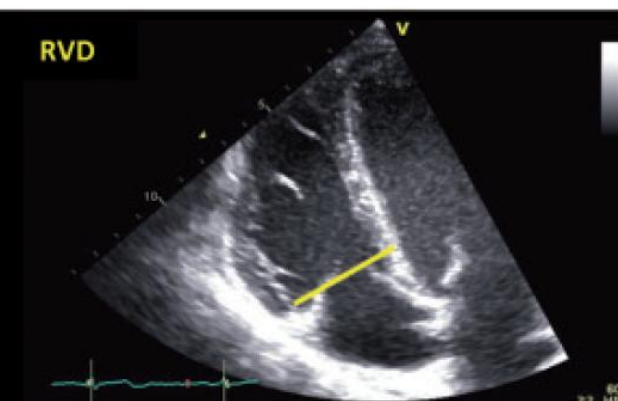
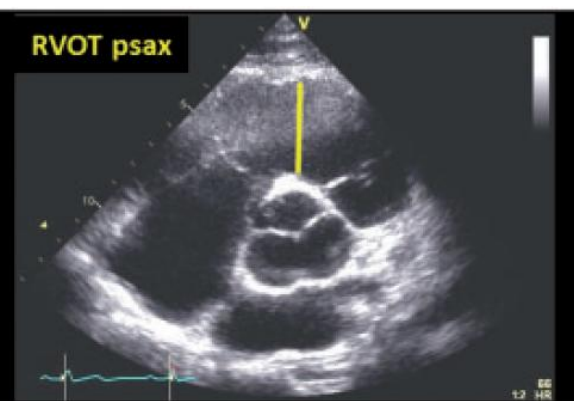
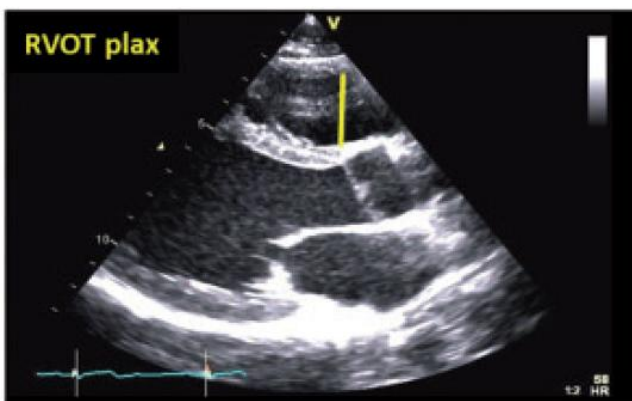
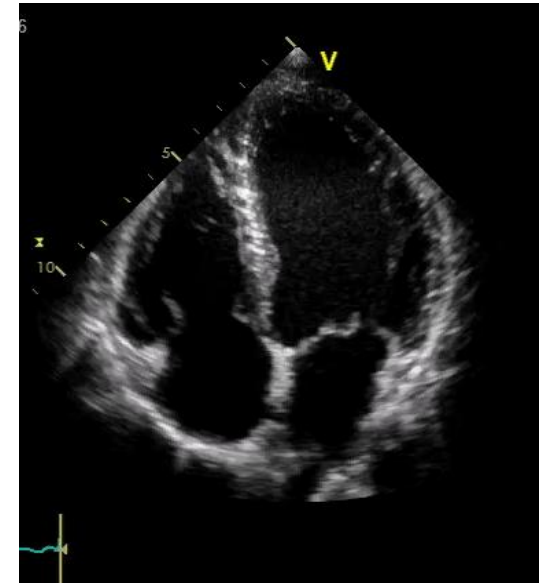
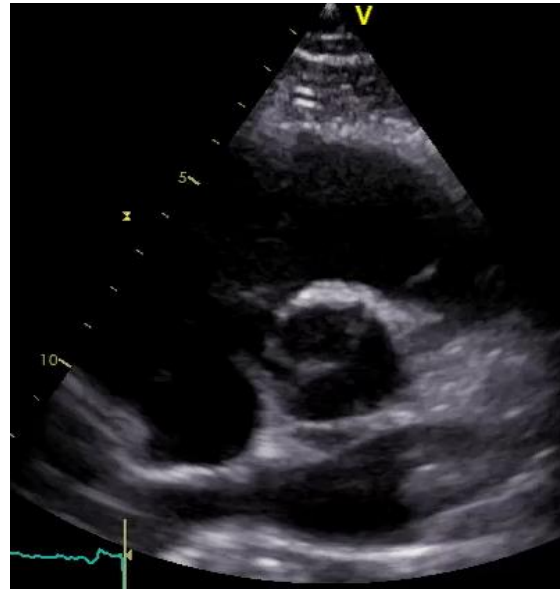
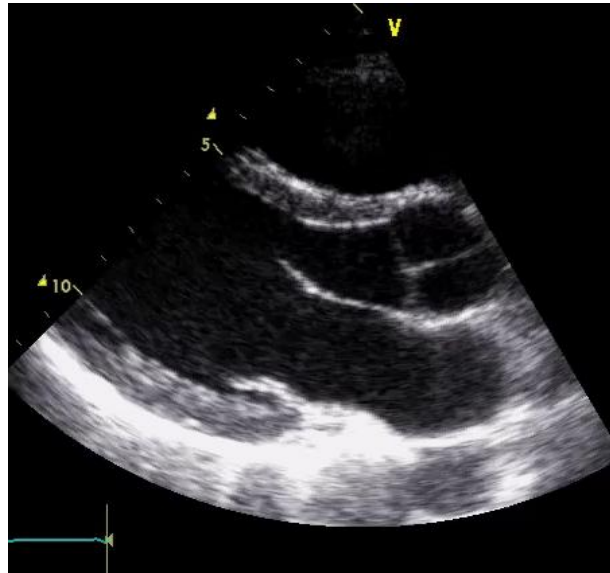
- Dilatace pravé komory (proporčně může být větší než levé komory)
- Normální funkce PK (snížení po zátěži)
- Dilatace pravé síně
- Dilatace VCI se sníženou kolapsibilitou
- Vyšší gradienty na TR (s vyšším odhadnutým PASP) – dané větším SV?

ARVC jako příčina náhlé smrti u sportovců?



HCM; Hypertrophic cardiomyopathy, IF; Idiopathic fibrosis, ILVH; Idiopathic left ventricular hypertrophy, ARVC; Arrhythmogenic right ventricular cardiomyopathy, CM; Cardiomyopathy.

Velikost pravé komory je významným kritériem pro dg. A(R)VC



Dilatace a dysfunkce PK tvoří jak „velká“ tak „malá“ kritéria pro dg. ARVC

Major

2D echo criteria

Regional RV akinaesia, dyskinaesia or aneurysm and one of the following measured at end diastole

PLAX RVOT ≥ 32 mm

PSAX RVOT ≥ 36 mm

Fractional area change $\leq 33\%$

Minor

2D echo criteria

Regional RV akinaesia or dyskinaesia and one of the following measured at end diastole

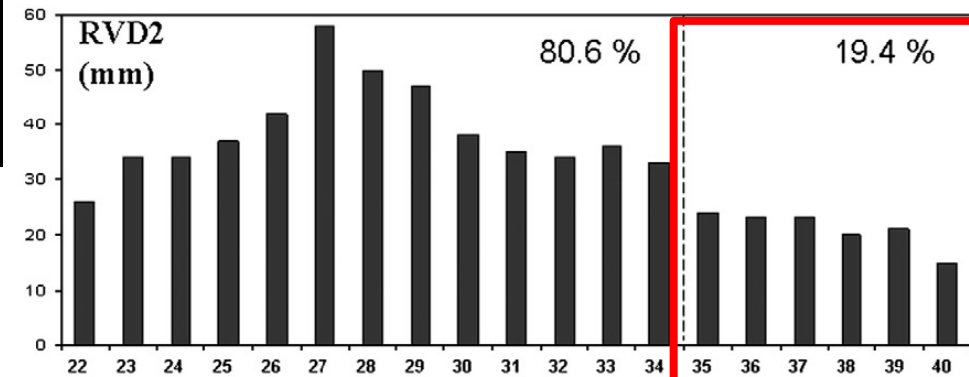
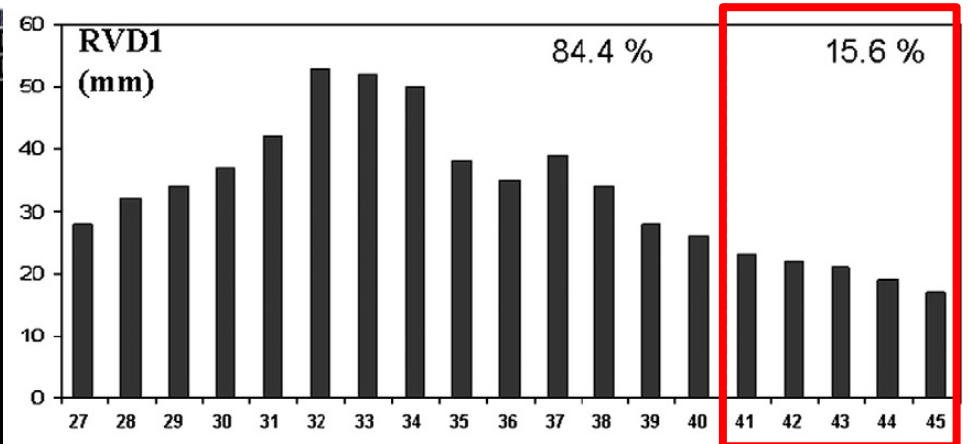
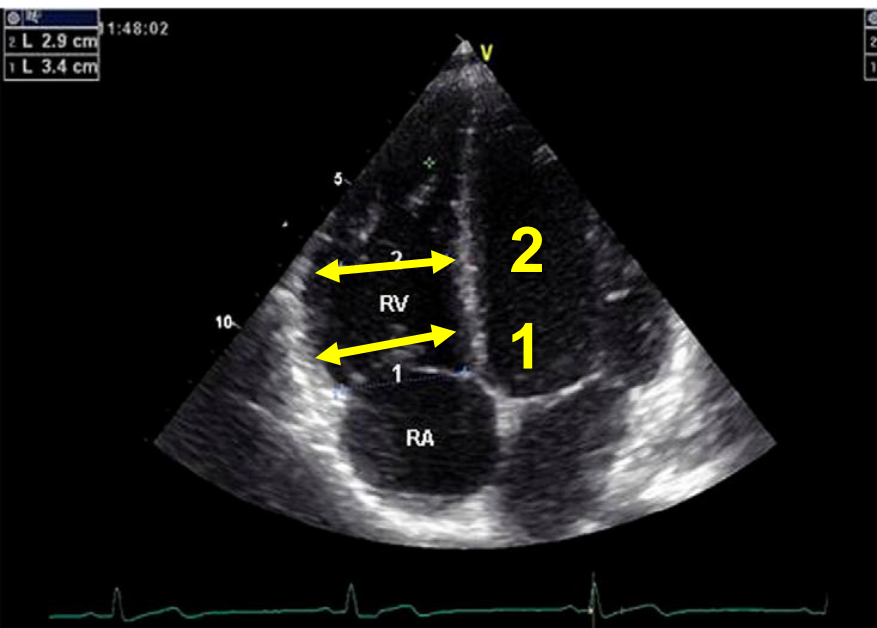
PLAX RVOT ≥ 29 to < 32 mm

PSAX RVOT ≥ 32 to < 36

Fractional area change $> 33\%$ to $\leq 40\%$

Dilatace PK u atletů

Analýza dat od 395 vytrvalostních a 255 silových atletů
230 kontrolních zdravých jedinců srovnatelného věku



Dilatace PK a PS zejména u vytrvalců.

Vyšší hodnoty PASP

Lepší relaxace PK

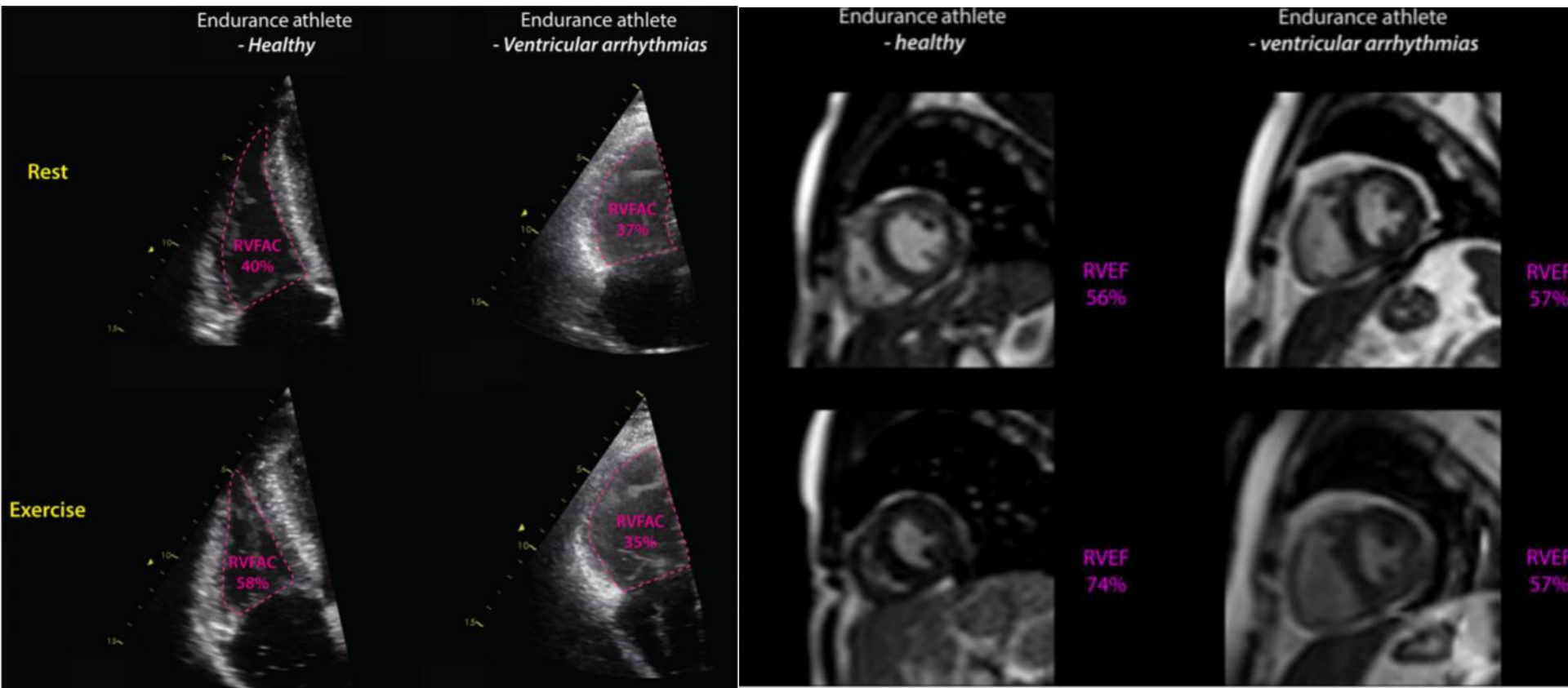
Cvičením indukovaná ARVC?

- 46 elitních atletů s komorovými arytmiemi – sledování 5 let
- 80% arytmií s morfologií LBBB
- Evidence abnormalit PK
 - manifestní u 59%
 - manifestní a podezřelá u 89%
- **Velké arytmiické příhody u 18**
- **Náhlá smrt u 9**
- ARVD rodinná anamnéza u 1

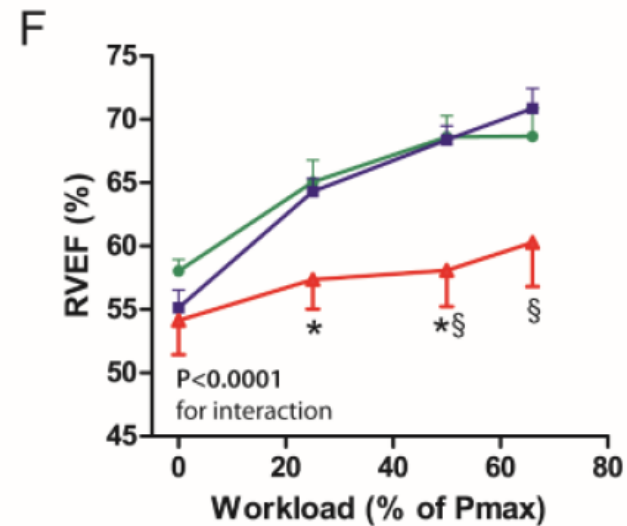
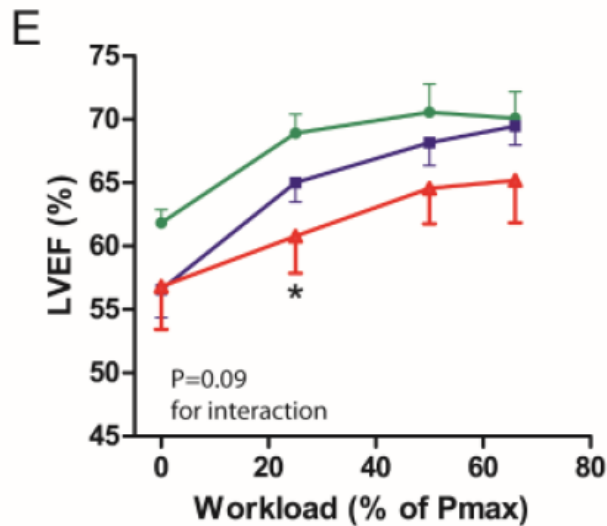
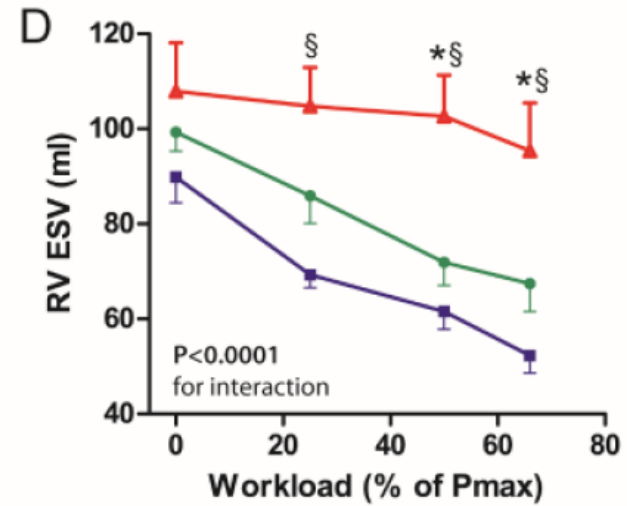
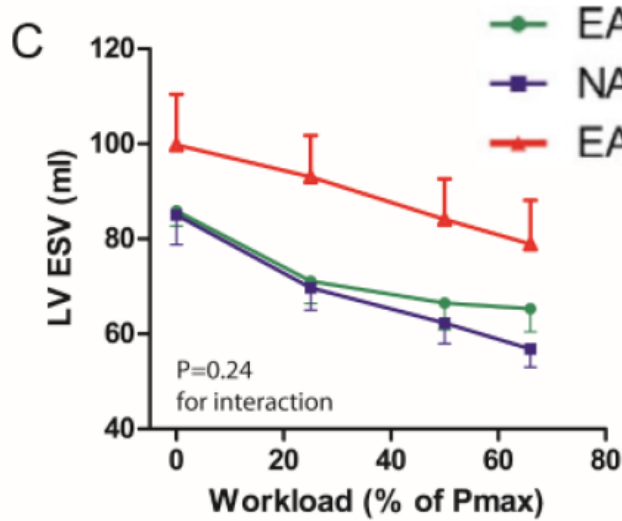
Menší než očekávaná četnost desmosomálních mutací u atletů s komorovými arytmiemi

- 47 atletů (42±11 let)
- Komplexní arytmie s morfologií z pravé komory
- Kritéria pro ARVC
 - Definitivní u 51%
 - Suspektní u dalších 36%
- Patogenní mutace pro ARVC 12,8%
- Předpoklad u ARVC 27-52%

Atleti s komorovými arytmiemi mají cvičením indukovanou dysfunkci PK



Atleti s komorovými arytmiemi mají cvičením indukovanou dysfunkci PK



Arrhythmia/Electrophysiology

Cardiac Arrhythmogenic Remodeling in a Rat Model of Long-Term Intensive Exercise Training

Begoña Benito, MD*; Gemma Gay-Jordi, PhD*; Anna Serrano-Mollar, PhD; Eduard Guasch, MD; Yanfen Shi, MD; Jean-Claude Tardif, MD; Josep Brugada, MD, PhD; Stanley Nattel, MD†; Lluís Mont, MD, PhD†

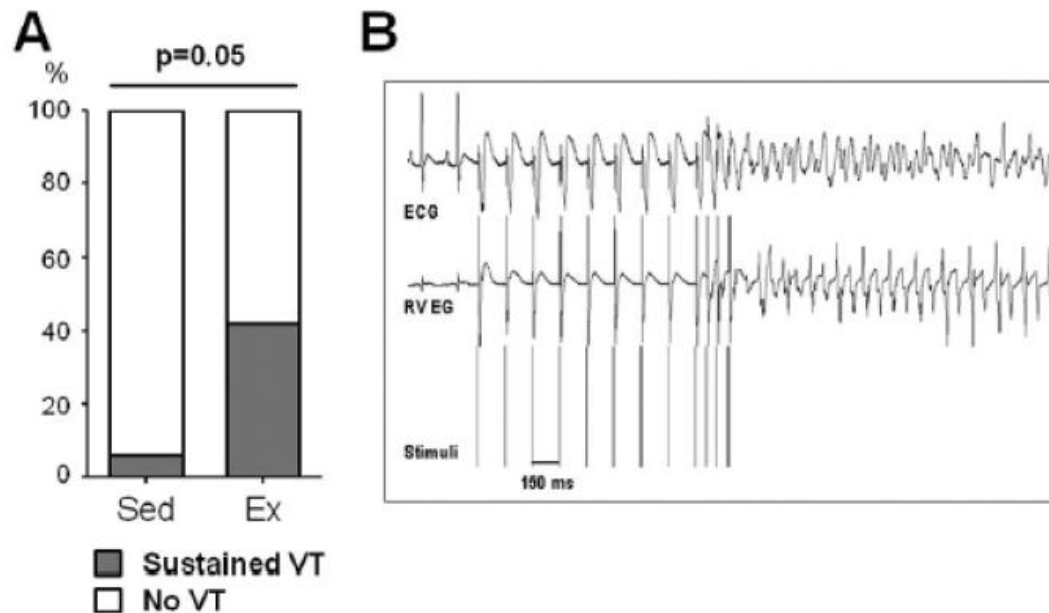
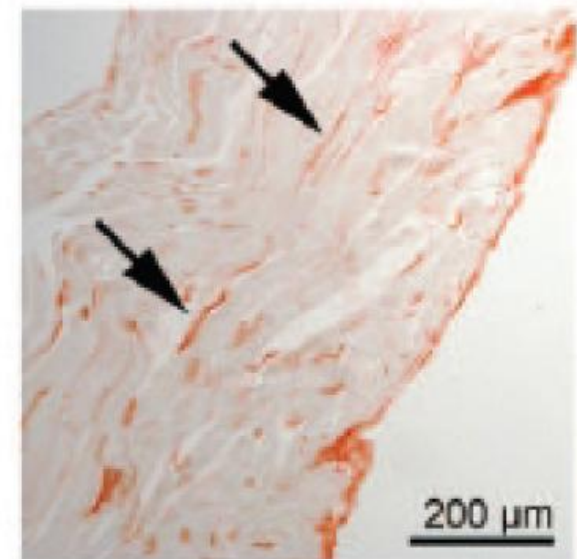
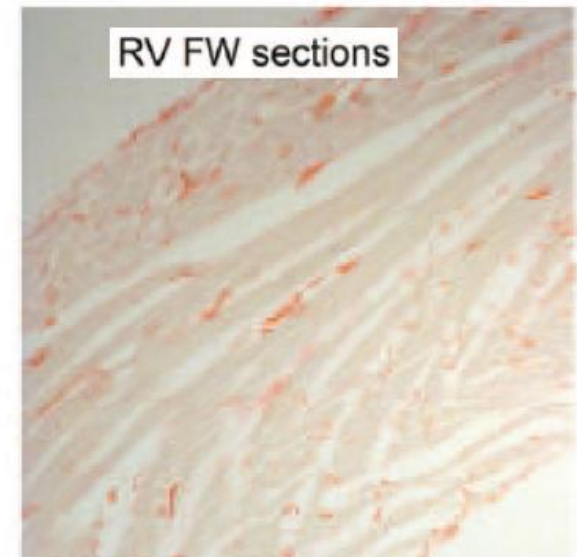


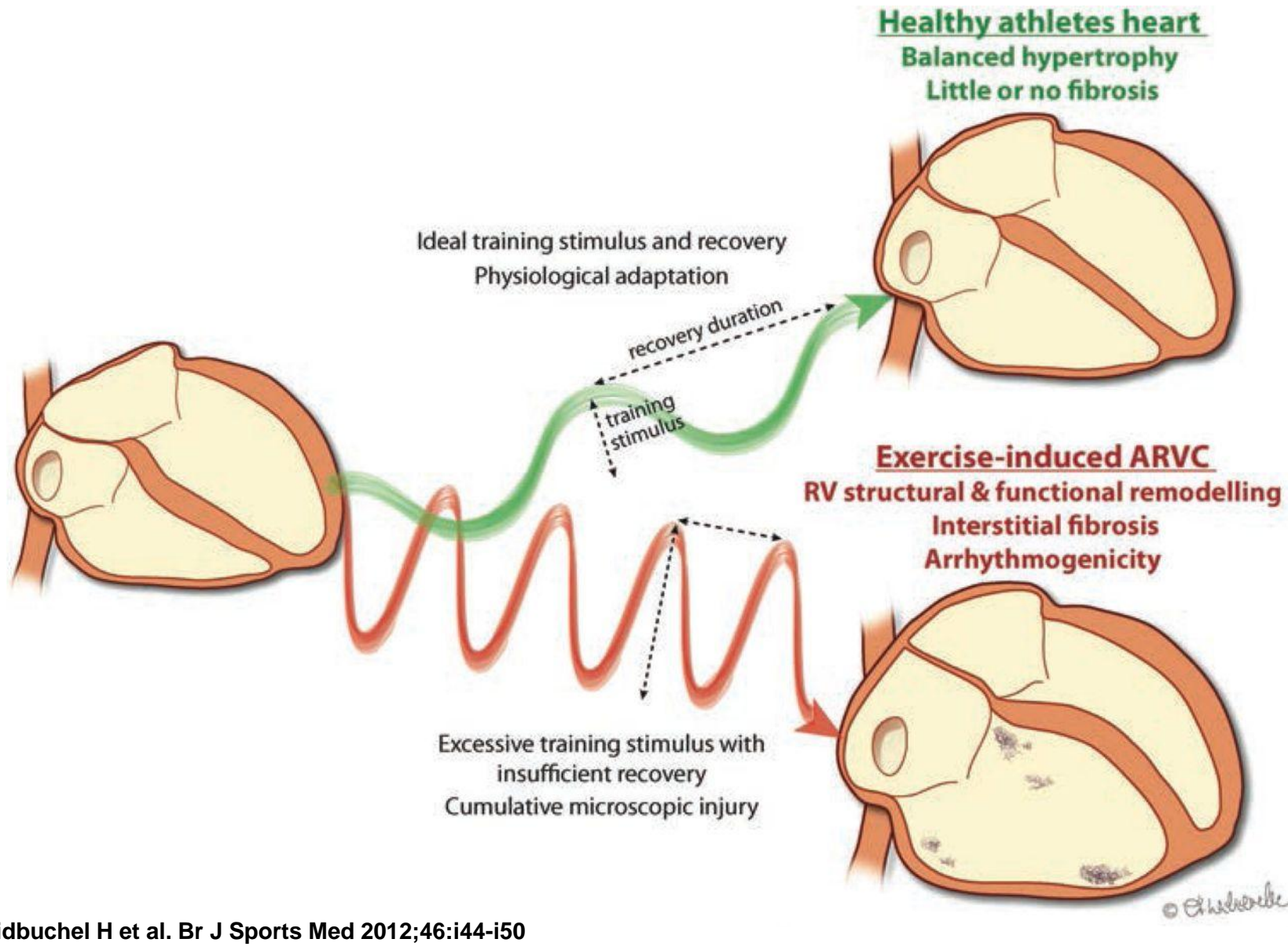
Figure 6. A, Inducibility of sustained (>10 seconds) ventricular arrhythmias by programmed electric stimulation; Fisher exact test, Ex vs Sed. B, Example of polymorphic ventricular tachyarrhythmias (VT) induction by ventricular stimulation in an Ex rat.

Benito et al., *Circulation* 2011;123:13-22

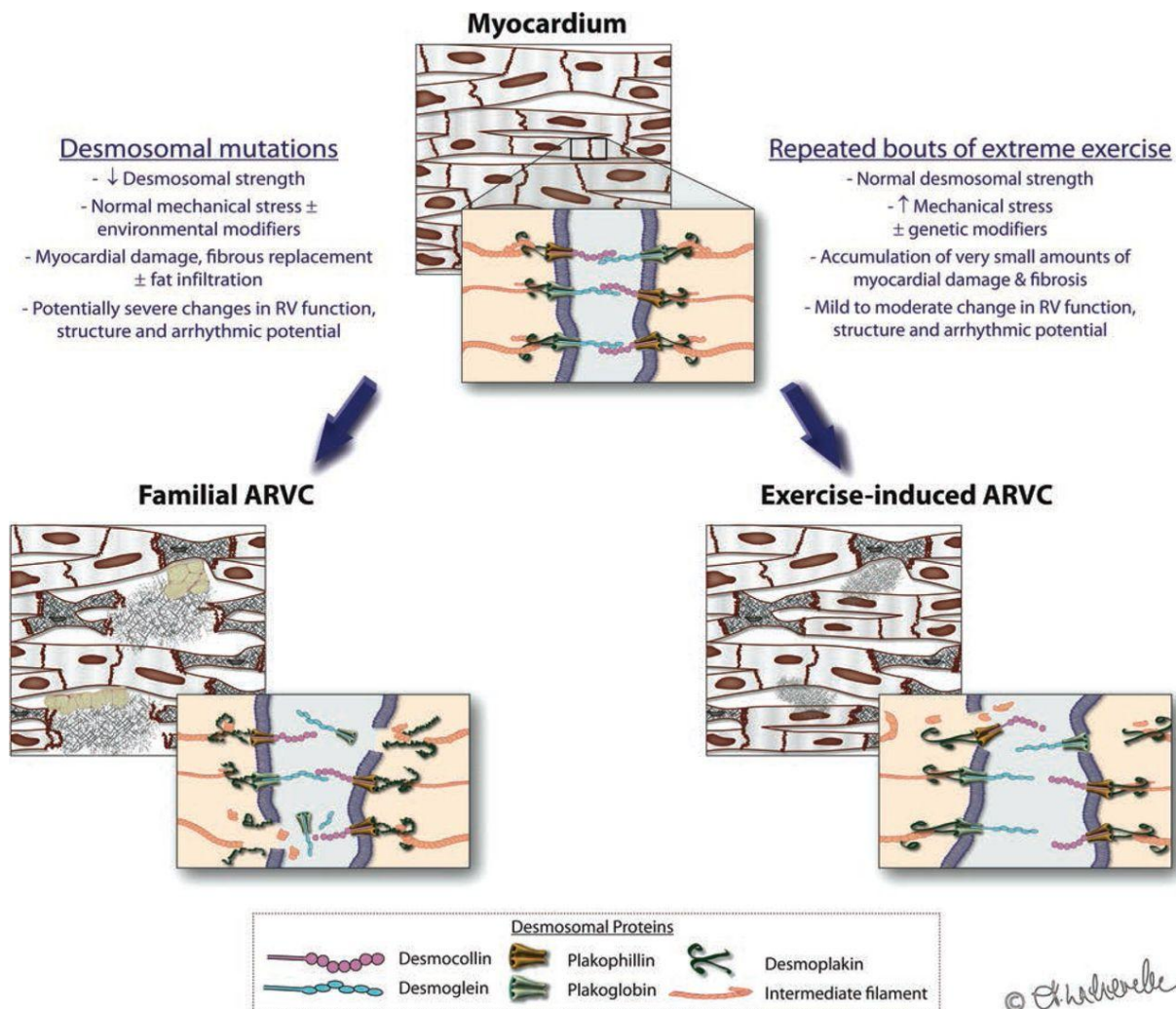
16 weeks



Zdravý trénink vs. přetrénování.

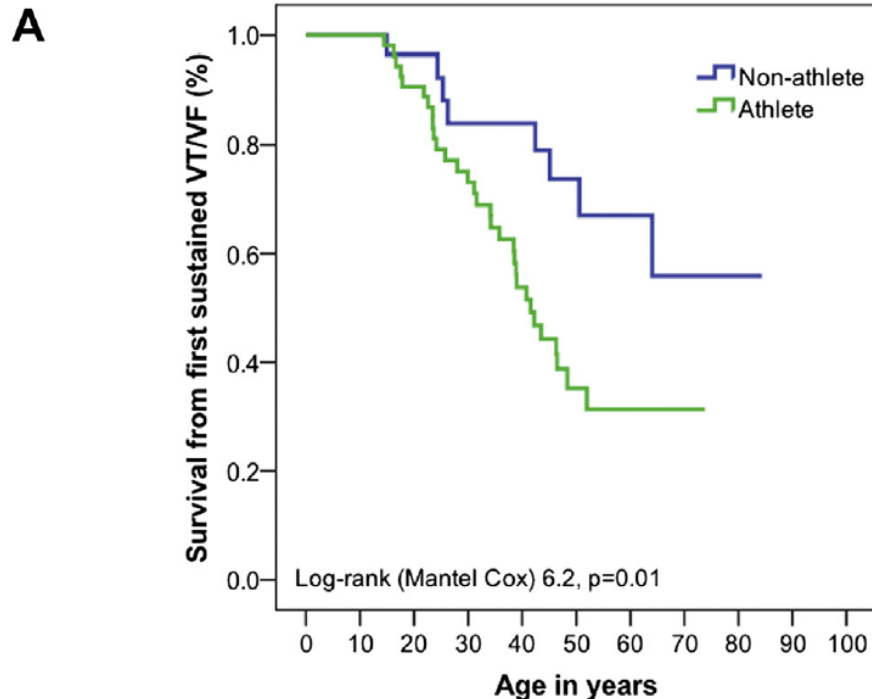


Familiální versus cvičením indukovaná ARVC: kontinuum? Celistvost junkcí mezi myocyty je kritickou podmínkou správné funkce myokardu.



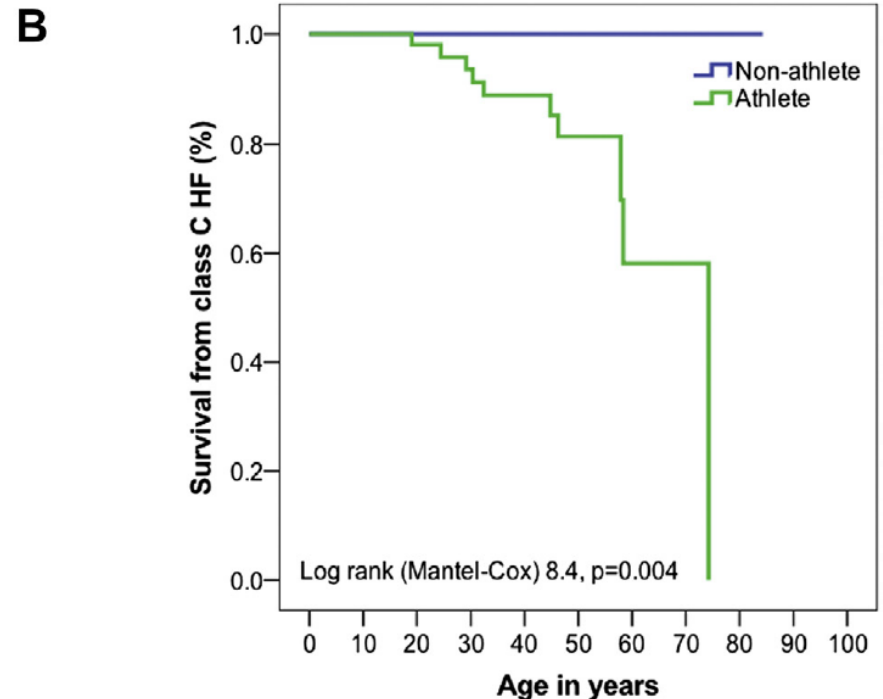
Cvičení urychluje nástup a zhoršuje průběh ARVC na podkladě desmosomálních mutací

Manifestace u atletů 30.1 ± 13.0 vs. u neatletů 40.6 ± 21.1 let



Numbers at risk

Non-athlete	31	31	24	20	18	11	9	3	1	0	0
Athlete	56	56	49	36	24	9	3	2	0	0	0



Numbers at risk

Non-athlete	31	31	24	22	18	11	9	4	1	0	0
Athlete	56	56	50	41	32	14	4	2	0	0	0

U atletů jsou časté i změny na EKG

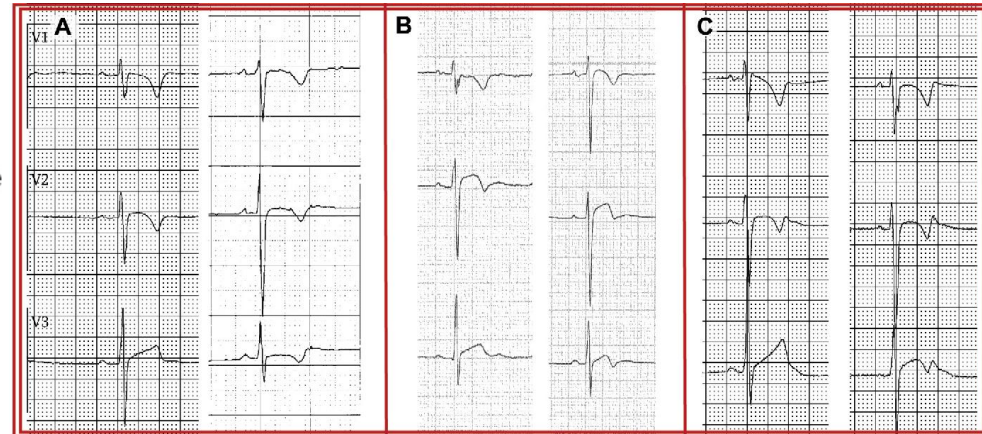
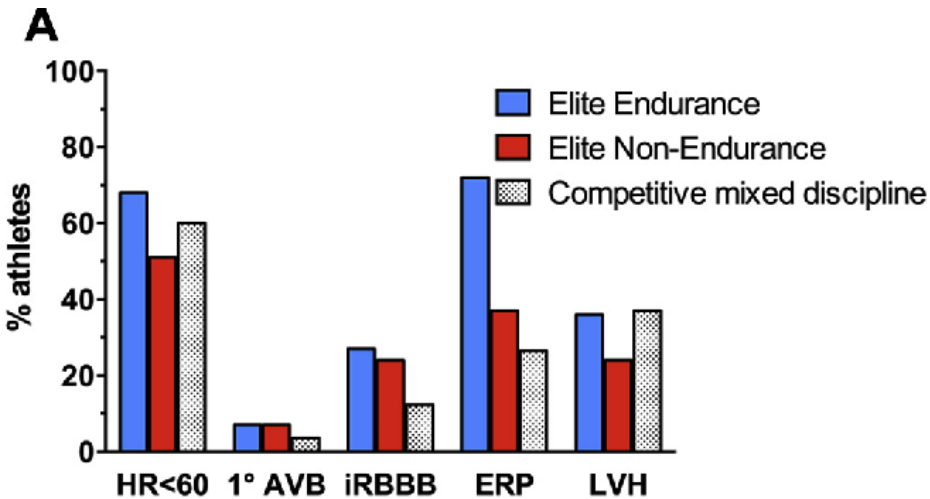
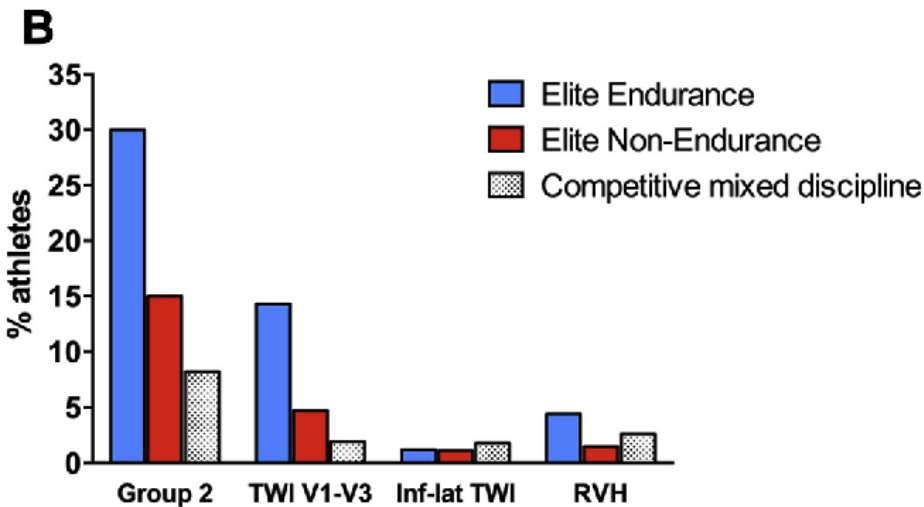


Figure 2. Examples of electrocardiograms demonstrating observed patterns of right precordial T-wave inversion (leads V₁ to V₃). (A) Deep, symmetrical



Inverze vlny T

– V2: 14.3% vs 4.7%

– V3: 4.0% vs 1.1%

Závěr

- U pravého srdce lze očekávat
 - Dilataci
 - Pokles systolické funkce po zátěži
 - Dilataci pravé síně
 - Dilataci VCI
- V řadě případů jsou nálezy nejednoznačné a překrývají se s dg. kritérii ARVC (dilatace, dysfunkce)
- Excesivní trénink může u vnímavých navodit fenotyp ARVC
- U atletů s arytmiemi z PK je morfologie upomínající ARVC častá aniž by měli prokazatelné mutace desmosomálních proteinů



Děkuji za pozornost....