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Introduction

- Cardiac remodeling consists of adaptive responses of the heart to a prolonged excessive physiological load or pathological stress
- Tennis players often engage in high-intensity drills and competitions
- Prolonged, intense endurance exercise can lead to increased stretching of the atrial muscle wall. The stretching potentially can result in irreversible cardiac remodeling, and therefore increases the risk of arrhythmias
- Currently, knowledge regarding cardiac remodeling in young tennis athletes remains sparse
- This study investigates cardiac remodeling in young tennis players

Methods

- Recruitment of 14 male college tennis players (with at least 3 years of experience, average age 8.3 ± 3.8 years, tennis group "Tennis") and 6 non-tennis college students (control group "Controls").
- Venous blood sampling, including tests for hematocrit, N-terminal pro B-type natriuretic peptide (NT-pro BNP), and creatine kinase (CPK) levels.
- Each participants completed the Cooper 12-minute run test for the calculation of VO_2 max using the formula: $VO_2 \text{ max} = (22.351 \times \text{kilometers}) - 11.288$ to obtain maximal oxygen consumption (VO_2 max) data.
- A comprehensive measurement of heart dimensions and function using real-time 3D echocardiography.

Results

Table 1. Demographics, VO_2 max, and laboratory data

Items	Controls (n=6)	Tennis (n=14)	P value
Age (years)	20.9 ± 3.0	22.5 ± 4.4	0.35614
Height (cm)	171.5 ± 5.60	175.4 ± 3.4	0.16172
Body weight (kg)	63.2 ± 8.4	68.8 ± 6.3	0.18378
Waist circumference (cm)	78.3 ± 8.8	79.8 ± 5.1	0.71668
Hip circumference (cm)	98.5 ± 9.0	98.5 ± 4.5	0.99295
Systolic BP (mmHg)	140.2 ± 8.7	130.9 ± 9.0	0.05697
Diastolic BP (mmHg)	83.3 ± 6.8	82.7 ± 8.8	0.86719
Pulse rate (beats/min)	86.8 ± 12.7	70.9 ± 7.0	0.02605
VO_2 max (mL/kg/min)	32.9 ± 6.9	43.4 ± 3.8	0.01129
12-minute run (meters)	1977.5 ± 306.1	2446.4 ± 169.4	0.01128
Laboratory data			
Hematocrit (%)	46.7 ± 2.3	45.6 ± 2.8	0.36496
NT-pro BNP (pg/mL)	17.8 ± 6.1	21.7 ± 11.0	0.53761
CPK (IU/L)	146.3 ± 61.1	182.5 ± 202.2	0.55137

*All values are expressed as Mean ± SD.

BP, blood pressure; VO_2 max, maximal oxygen uptake; 12 min run, maximum distances that participants can run in 12 minutes; BNP, brain natriuretic peptide; CPK, Creatine-phospho-kinase.

Table 2. Dimensional measurements in the echocardiography

Items	Controls (n=6)	Tennis (n=14)	P value
Aorta (cm)	3.18 ± 0.26	3.15 ± 0.33	0.81389
Left Ventricle (LV)			
IVSd (cm)	0.86 ± 0.10	0.93 ± 0.11	0.22136
LVIDd (cm)	4.90 ± 0.29	5.01 ± 0.39	0.51585
LVIDs (cm)	3.03 ± 0.18	3.16 ± 0.28	0.21434
LVPWd (cm)	0.81 ± 0.04	0.90 ± 0.06	0.00080
LVPWs (cm)	1.55 ± 0.18	1.56 ± 0.16	0.88671
LV mass (g/m ²)	79.38 ± 7.65	88.66 ± 14.78	0.08297
FS (%)	38.22 ± 3.26	36.82 ± 3.63	0.41555
LVEDV (mL)	134.83 ± 20.31	142.43 ± 15.37	0.43682
LVESV (mL)	56.83 ± 13.83	55.21 ± 10.39	0.80386
LVEF (%)	58.17 ± 5.19	61.57 ± 4.86	0.20421
Right Ventricle (RV)			
FAC (%)	38.78 ± 4.66	40.72 ± 7.25	0.49449
TAPSE (mm)	10.80 ± 5.20	11.78 ± 10.39	0.78819
RVEDV (mL)	110.05 ± 21.92	142.34 ± 17.34	0.01292
RVESV (mL)	62.70 ± 12.58	76.26 ± 12.44	0.05246
RVEF (%)	42.87 ± 3.66	46.70 ± 5.74	0.09423
Left Atrium (LA)			
LA Diameter (cm)	3.15 ± 0.34	3.46 ± 0.49	0.12204
LA Volume (mL)	36.07 ± 5.97	49.36 ± 10.80	0.00276
LA Volume Index (ml/m ²)	20.85 ± 2.91	26.93 ± 5.51	0.00518
LAEF (%)	66.50 ± 9.41	61.57 ± 9.21	0.25300

*All values are expressed as Mean ± SD.

IVSd, interventricular septum thickness at end-diastole; LVIDs, Left ventricular internal diameter at end-systole; LVIDd, Left ventricular internal diameter at end-diastole; LVPWs, left ventricular posterior wall thickness end-systole; LVPWd, left ventricular posterior wall thickness end-diastole; LV mass, derived by cube (Teichholz) formula; FS, fractional shortening; LVESV, left ventricular end-systolic volume; LVEDV, left ventricular end-diastolic volume; LVEF, left ventricle ejection fraction; RVESV, right ventricular end-systolic volume; RVEDV, right ventricular end-diastolic volume; FAC, fractional area change; TAPSE, tricuspid annular plane systolic excursion; LAEF, left atrial emptying fraction.

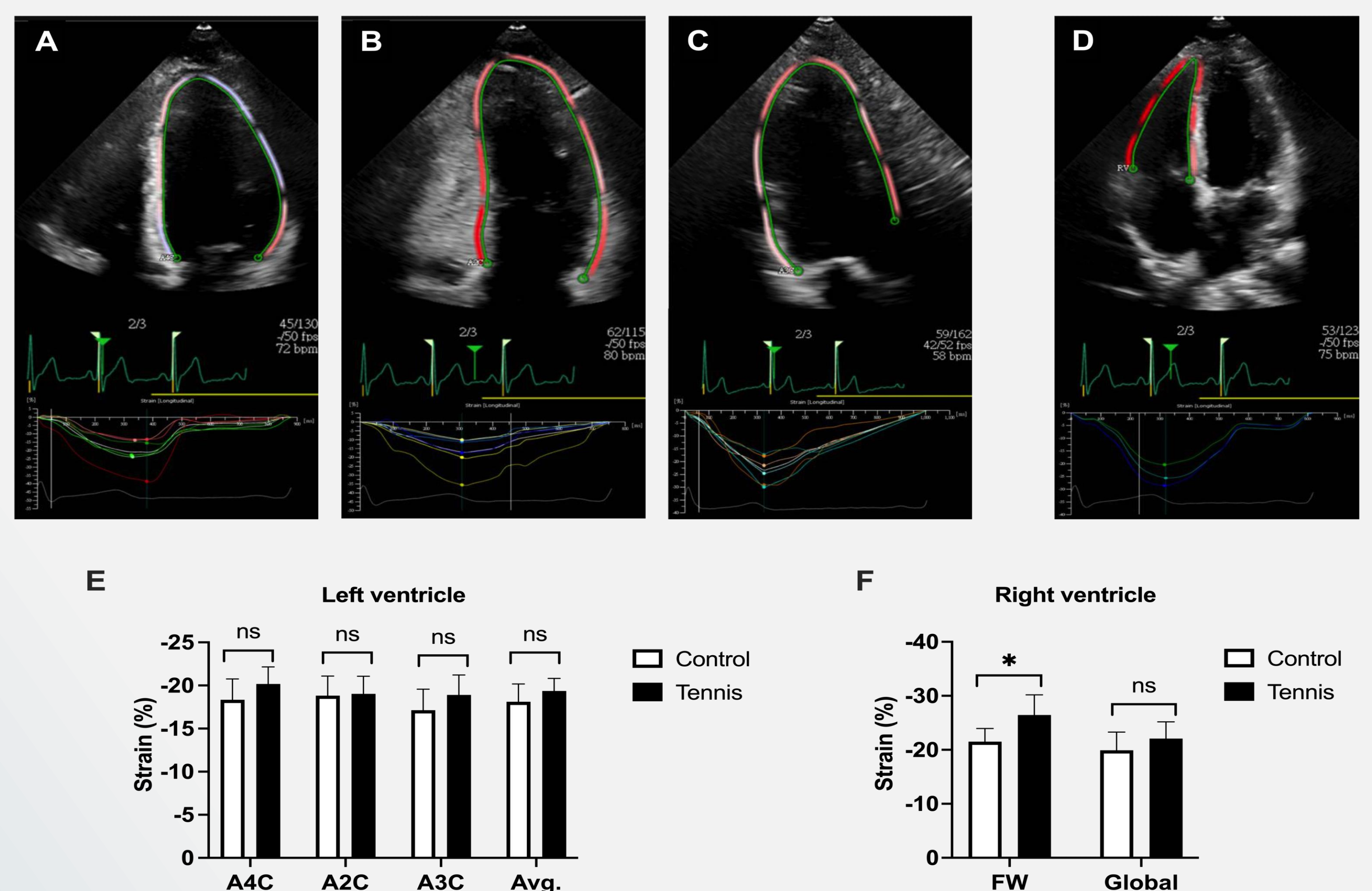


Figure 1. Longitudinal strain of left and right ventricles and analysis.

Left ventricle global longitudinal strain analysis in A4C view (A), A2C view (B), and A3C view (C). The RV free wall longitudinal strain analysis in the RV-focused 4-chamber view (D). There is no difference between two groups for the LV longitudinal strain (E). The Tennis group has larger RV strain for the free wall (FW)(F).

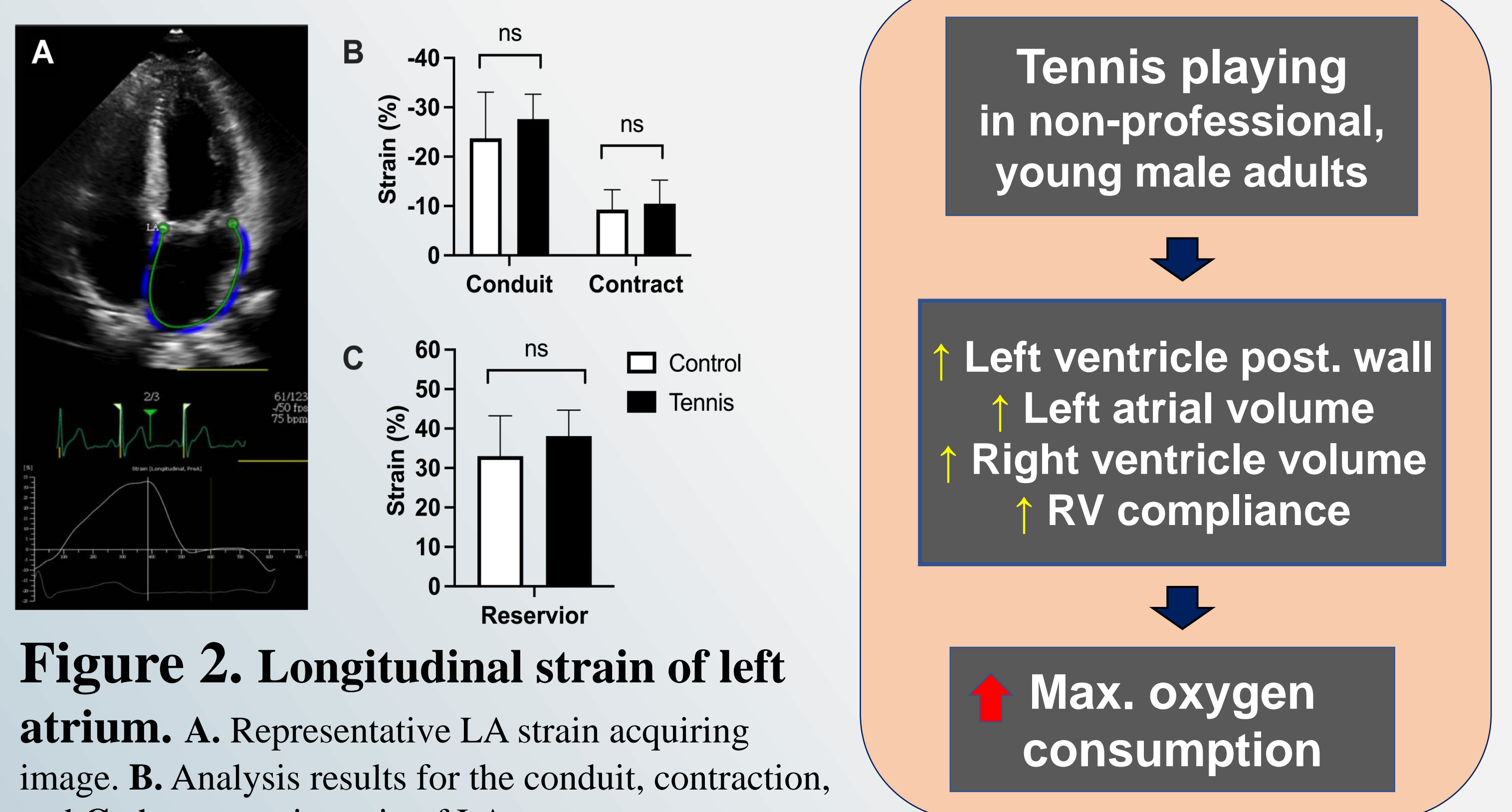


Figure 2. Longitudinal strain of left atrium. A. Representative LA strain acquiring image. B. Analysis results for the conduit, contraction, and C. the reservoir strain of LA.

Conclusions

- In young adults, tennis drills leads to significant cardiac remodeling, with increase of left atrial volume, right ventricular volume, and left ventricular posterior wall thickness.
- The left atrial and left ventricular function are unchanged.
- The enhanced right ventricular strain can contribute to the increased VO_2 max (maximal oxygen consumption) in young tennis players.
- The dilated left atrium has preserved strain.
- The results suggest that tennis drills do not induce any adverse cardiac remodeling in young players.