and mid-ventricular diameter, as well as greater RV end-diastolic and end-systolic area (Table). Athletes had greater VO2 max.

Table 1

	Athletes (n=76)	Controls (n=25)	P-value
VO_2 max indexed, mL/kg/min	62±7	44±5	<0.001
RV basal diameter/BSA, mm/m^2	28±3	25±4	<0.001
RV mid-cavity diameter/BSA, mm/m^2	24±3	22±3	<0.01
RV end-diastolic area/BSA, cm^2/m^2	14.7±2.9	13.1±1.3	<0.01
RV end-systolic area/BSA, cm^2/m^2	8.5±1.8	7.5±0.9	<0.01
RV global longitudinal strain, %	28±4	31±3	<0.01
RV fractional area change, %	42±6	43±4	0.52
LV global longitudinal strain, %	23±2	23±2	0.36
LV ejection fraction, %	58±3	58±3	1.00

Data expressed as mean ± SD. Right column shows P-values for Student's t-test. BSA, body surface area; LV, left ventricular; RV, right ventricular.

Conclusion: Increasing attention is being paid to the potential consequences of the remodeling seen in the heart of endurance athletes. This study supports the notion that cardiac changes are occurring as early as in preadolescent athletes, and that RV function might be key in evaluating and monitoring this growing population.

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P653

Cardiac remodeling in highly trained athletes is associated with rho kinase activation and increased levels of cardiotrophin-1

L. Gabrielli[1], R. Saavedra[1], S. Herrera[1], J. Vega[1], M. Salinas[1], R. Fernandez[1], F. Contreras[1], L. Vergara[1], F. Yanez[1], J. Jalil[1], M.P. Ocaranza[1], S. Lavandero[2], M. Chiong[2], P. Castro[1], M. Sitges[3]. [1]*Pontifical Catholic University of Chile, Cardiovascular Disease Division, Santiago, Chile;* [2]*University of Chile, Advanced Center for Chronic Diseases (ACCDiS) & CEMC, Facultad Ciencias Químicas y Farmacéuticas y F, Santiago, Chile;* [3]*Institute of Biomedical Research August Pi Sunyer (IDIBAPS), Cardiology Department, Barcelona, Spain*

Introduction: Highly trained athletes show structural cardiac changes as adaptation to an overload condition sustained over time. Although the activity of Rho-kinase (ROCK) and cardiotrophin-1 (CT-1) levels have been associated with cardiovascular remodeling in different clinical scenarios it remains unknown their roles in highly trained athletes. The aim was to assess levels of ROCK activation and CT-1 levels in marathon runners during their training period previous to a 42 k marathon run.

Methods: Pilot, single blinded study that included 16 healthy male marathon runners registered for the Santiago Marathon (42 km). Athletes were allocated into two groups according to their previous trainning level: Group 1 ≥100 km/week; Group 2 <100 km/week. Also, a sedentary control group matched by age, sex and body mass index was included. All subjects underwent transthoracic echocardiography. ROCK activity was determined in circulating leukocytes by measuring myosin phosphatase 1 phosphorylation (p/t-MYPT1; Western-blot) and plasma CT-1 levels were measured by ELISA. Kruskal-Wallis and Mann-Whithney U test were used.

Results: Mean age was 39±6.5 years. See table.

	Controls (n=12)	Group 1 (n=8)	Group 2 (n=8)	p value
p/t-MYPT1	0.87±0.30†	4.22±1.96*	2.09±1.64	0.013
CT-1 (pg/mL)	18±5	135±209*	21±7	0.004
Left ventricle mass index (gr/m^2)	69±10	91±21*	73±12	0.04
Left atrial volume index (mL/m^2)	29.3±4.2	39.4±12.6*	30.6±4.6	0.04
Left ventricle ejection fraction (%)	60.5±4.3	55.8±3.3	58.6±6.7	0.3
E wave (cm/sec)	80.7±5.9	81.7±9.8	88.1±14.2	0.31
A wave (cm/sec)	55.3±9.1	51.5±14.3	53.4±12.5	0.76

Mean ± SD. *p<0.05 post hoc test vs other groups; †p=0.03 post hoc test vs group 2.

Conclusion: Highly trained athletes have increased ROCK activity and CT-1 levels as compared to sedentary subjects. Those marathoners with a higher training load prior to a race exhibit greater ROCK activity and CT-1 levels which was associated with higher left ventricle mass and left atrial size. These biomarkers may be involved in the development of cardiovascular remodeling observed in highly trained athletes.

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P654

Left and right ventricle longitudinal strains are dependent of the preload in middle-aged ultratrailers

A. Gudjoncik[1], F. Chague[1], C. Guenancia[1], F. Compagnon[2], C. Richard[1], O. Ganansia[3], V. Pasquereau[4], M. Zeller[5], Y. Cottin[1]. [1]*University Hospital of Dijon, Cardiology department, Dijon, France;* [2]*General Hospital, Emergency, Coulommiers, France;* [3]*Saint-Joseph Hospital, Emergency department, Paris, France;* [4]*General Hospital, Intensive Care Unit, Mantes, France;* [5]*University of Bourgogne Franche-Comté, PEC2, EA 7460, Dijon, France*

Background: Alteration of both ventricles contractility indexes has been described after ultra-long duration exercise (ULDE). In these races, preload can dramatically vary. This could interfere with analysis when investigating cardiac function of these athletes.

Purpose: We aimed to change the preload of ultra-trailers and analyse their systolic left-ventricle (LV) and right-ventricle (RV) function.

Methods: We performed echocardiography at rest in amateur ultra-trailers in three different positions: 0° inclination (P1), head-up and legs-down (P2) and then Trendelenburg position (P3). Preload was analysed using Doppler LV diastolic parameters and LV end-diastolic volume (LVEDV) estimated by the biplane Simpson method. We analysed systolic LV global longitudinal strain (LVGLS) and free wall RV longitudinal strain (FWRVLS). Heart rate (HR) and systolic blood pressure (SBP) – used as a reflect of afterload - were automatically recorded during echocardiographic assessment. Statistical analyses were performed using ANOVA repeated measures.

Results: 22 ultra-trailers (mean age 47.9±6.5, mean BMI 24.2±2.0) underwent an echocardiographic assessment in the three positions. HR, SBP and E/A did not vary. E/Ea was greater in P3 than in P2 (p=0.016), LVDV greater in P3 than in P1 (p=0.025) and in P2 (p=0.012). LVGLS was improved in P3 when compared to P1 (p=0.001) and P2 (p<0.001). FWRVLS (only 21 athletes recordings available) was impaired in P2 when compared to P1 (p=0.013) and P3 (p=0.011). Results are summarized in table1.

Main results

	HR (mn^{-1})	SBP (mmHg)	E/A	E/Ea	LVEDV (ml)	LVGLS (%)	FWRVLS (%)
P1	61.3±8.1	136.5±10.7	1.43±0.61	5.62±0.94	106.0±17.5	-20.7±2.2	-26.7±5.7
P2	60.1±7.7	135.3±14.4	1.26±0.45	5.27±1.20	104.2±19.2	-20.0±2.5	-23.1±4.6**
P3	61.6±7.6	135.3±11.3	1.39±0.40	6.02±0.91*	118.5±13.8* **	-22.5±2.8* **	-26.2±3.6*

*Statistically different from P2; **statistically different from P1.

Conclusions: Changes in E/Ea ration and LVEDV were highly suggestive of efficacy of the method to induce a change in preload while HR and afterload did not vary. LVGLS and FWRVLS appeared to be modified by preload conditions. This dependency must be taken in account when assessing cardiac function after ULDE.

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P655

Three-dimensional morphology and mechanics of the left ventricle and the left atrium in adolescent athletes

A. Kovacs, B.K. Lakatos, N. Sydo, A.A. Molnar, M. Tokodi, D. Major, M. Babity, O. Kiss, B. Merkely. *Semmelweis University, Heart and Vascular Center, Budapest, Hungary*

Regular physical exercise results in complex morphological and functional remodelling of the left ventricle (LV) and also the left atrium (LA), however, conventional echocardiographic parameters offer limited power to assess subtle features of athlete's heart compared to non-trained individuals. Three-dimensional (3D) echocardiography may overcome these limitations enabling an accurate volumetric quantification and mechanical characterization of both the LV and the LA.

Accordingly, our aim was to characterize exercise-related adaptation of the LV and the LA in adolescent athletes using 3D echocardiography.

Fifty adolescent male soccer players (16±1 years, 10 hours training/week in average) were enrolled and compared to 20 age-matched sedentary male volunteers. Full volume 3D datasets reconstructed from 4 or 6 cardiac cycles, focused on the LV and the LA were acquired. Using dedicated 3D software (TomTec 4D LV-Analysis with prototype LA option) to contour and track the endocardial border of the LV and the LA, we have determined LV end-diastolic volume (LVEDV), LV ejection fraction (LVEF), LA volume (LAV), LA ejection fraction (LAEF) and LA passive and active ejection fraction (active EF, passive EF). By speckle-tracking analysis of the 3D models, we quantified LV global longitudinal strain (LVGLS) and LA reservoir strain (LArS) as well. Athletes also underwent cardiopulmonary exercise testing to measure peak oxygen uptake (VO2/kg).

Athletes had significantly higher LVEDV and LAV compared to controls (athlete vs. control; LVEDV: 161±25 vs. 118±21 mL, LAV: 56±12 vs. 42±9 mL, both p<0.0001). LVEF was similar in the two groups (57±4 vs. 59±3%, p=NS). LAEF, passive EF and active EF were also comparable between the groups (LAEF: 56±9 vs. 55±8%, passive EF: 44±8 vs. 42±9%, active EF: 22±11 vs. 22±10%, all p=NS). LVGLS did not differ between athletes and controls either (-20±2 vs. -20±3%, p=NS), however, athletes demonstrated significantly higher LA reservoir strain (LArS: 32±8 vs. 27±6%, p<0.05). In athletes, lower resting LV myocardial mechanics was associated with a better peak exercise capacity (LVGLS vs. VO2/kg: r=0.37, p<0.05).

Volumetric and mechanical characterization of the left heart using 3D echocardiography may provide a better understanding of exercise-related morphological and functional changes. In adolescent athletes, LV and LA function quantified by ejection fraction is similar to non-trained controls, despite marked dilation of both cardiac chambers. However, LA reservoir function is supernormal. Moreover, resting myocardial mechanics may show correlation with peak exercise capacity.