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 Effect of long-term soccer training on changes in cardiac function during exercise in elite youth soccer players

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Article

Tables

Table 1: Relative Exercise Intensities for Soccer Players (SP) vs Controls (CON) across all 3 years. All values are mean ± SD.

	YEAR 1	YEAR 2	YEAR 3
Relative Exercise Intensity ($\%\dot{V}O_{2peak}$)	SP:46.8 ± 5.6% vs CON: 46.5 ± 7.9%	SP:43.9 ± 9.9% vs CON: 47.3 ± 7.4%	SP: 46.3 ± 8.0% vs CON: 42.3 ± 12.3%.

Table 2: Cardiovascular and Tissue-Doppler Measurements at the same relative exercise intensity within and between years across the 3 years of the study. All values are mean ± SD.

	Soccer Players Year 1	Soccer Players Year 2	Soccer Players Year 3	Control Year 1	Control Year 2	Control Year 3
n	22	19	18	15	12	12
Heart rate (bpm)	106 ± 14	122 ± 11	111 ± 17	103 ± 16	110 ± 13	115 ± 15
n	22	19	18	15	12	12
QIndex (L/min/m²)	6.13 ± 0.76	6.94 ± 1.31	7.20 ± 1.81	5.15 ± 1.12	4.67 ± 1.04	5.49 ± 1.06
n	22	19	18	15	12	12
SVIndex (mL/m²)	60 ± 12	58 ± 11	64 ± 10	50 ± 5.	44 ± 12	47 ± 7
n	22	19	16	15	12	12
A VO₂ Difference (mL.100mL⁻¹)	11.3 ± 1.5	10.0 ±1. 7	10.5 ± 2.0	11.5 ± 2.4	11.7 ± 3.1	9.3 ± 1.5
n	22	19	18	15	12	12
Peak Aortic Velocity (cm/s)	186.7 ± 24.5	200.2 ± 21.2	200.1 ± 32.6	149.5 ± 25.9	155.7 ± 23.9	177.1 ± 28.8
n	12	19	18	15	12	12
S' adj (cm/s/mm)	0.18 ± 0.03	0.22 ± 0.03	0.17 ± 0.05	0.17 ± 0.03	0.15 ± 0.02	0.19 ± 0.05
n	22	19	18	15	12	12
E (cm/s)	129 ± 12	143 ± 16	135 ± 18	113 ± 10	111 ± 12	121 ± 9

n	22	19	18	15	12	12
E' adj (cm/s/mm)	0.25 ± 0.04	0.25 ± 0.04	0.23 ± 0.05	0.23 ± 0.04	0.22 ± 0.03	0.22 ± 0.05
n	22	19	18	15	12	12
E/E'	6.9 ± 1.1	7.8 ± 0.6	7.3 ± 1.1	6.7 ± 0.9	6.8 ± 1.0	7.4 ± 1.2

(QIndex) Cardiac output adjusted for body surface area , (SVIndex) Stroke volume adjusted for body surface area, (AVO$_2$) Arterial venous oxygen difference, (E) Peak early diastolic filling velocity, Peak longitudinal mitral annular velocities in systole (S') and early diastole (E'). Both E' and S' were adjusted (adj) for heart size by LV length. E/E was calculated as an estimate of LV filling pressure and thus preload.

Table 3: Influence of training at each year for the Outcome Variables. All values are Coefficient (p-value). The model is adjusted for individual maturity offset values in each year.

	Year 1 Group (Soccer Player)	Year 2 Group (Soccer Player)	Year 3 Group (Soccer Player)	Interaction
Heart rate (bpm)	3.0 (p=0.590)	25 (p<0.001)*	-4.0 (p=0.460)	p<0.001*
QIndex (L/min/m^2)	0.95 (p=0.010)*	2.67 (p<0.001)*	1.72 (p<0.001)*	p=0.012*
SVIndex (mL/m^2)	11 (4, 17)$^\Sigma$			p=0.378
A-VO$_2$ Difference (mL.100mL^{-1})	0.0 (p=0.990)	-1.4 (p=0.350)	1.1 (p=0.120)	p=0.043*
Peak Aortic Velocity (cm/s)	34.5 (p=0.010)*	47.4 (p<0.001)*	24.0 (p=0.040)*	p=0.046*
S' adj (cm/s/mm)	0.00 (p=0.770)	0.10 (p<0.001)*	-0.02 (p=0.270)	p<0.001*
E (cm/s)	17 (p<0.001)*	43 (p<0.001)*	15 (p=0.010)*	p<0.001*
E' adj (cm/s/mm)	0.01 (p=0.310)	0.08 (p<0.001)*	0.01 (p=0.660)	p=0.008*
E/E'	0.1 (-0.5, 0.8)			p=0.205

(QIndex) Cardiac output adjusted for body surface area , (SVIndex) Stroke volume adjusted for body surface area, (AVO$_2$) Arterial venous oxygen difference, (E) Peak early diastolic filling velocity, (S') Peak longitudinal mitral annular velocities in systole and (E') early diastole. Both E' and S' were adjusted (adj) for heart size by LV length. E/E was calculated as an estimate of LV filling pressure and thus preload.

*For those with a Group (SP. CON) x Year (1, 2, 3) interaction the effect of training was estimated at each year separately. But in the absence of a significant Group x Year interaction, but a significant effect of Group (Σ) the influence of training followed the same pattern over the three years for SVIndex and the average coefficient was estimated. No Group x Year or Group effect was identified for E/E'.

Table 4 illustrates the observed mean ± SD for SP and CON from years 1-3 at approximately the same relative exercise intensity within and between each year for all strain data.

	SP Year 1	SP Year 2	SP Year 3	CON Year 1	CON Year 2	CON Year 3
Peak ε (%)	-19.93 ± 3.33	-18.91 ± 3.67	-18.05 ± 2.41	-20.46 ± 2.50	-18.32 ± 2.70	-18.92 ± 3.55
SSR (1/s)	-1.44 ± 0.18	-1.56 ± 0.45	-1.37 ± 0.24	-1.33 ± 0.22	-1.35 ± 0.20	-1.59 ± 0.06
DSR (1/s)	2.20 ± 0.49	2.57 ± 0.63	2.01 ± 0.45	2.15 ± 0.40	2.18 ± 0.50	2.32 ± 0.76

(ε) Peak longitudinal strain, (SSR) strain rate during systole and (DSR) strain rate during diastole