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EchoAGE: Echocardiography-based Neural Network model forecasting Heart Biological Age

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Supplementary Table 1. Correlations of potential predictors.

Description	Unit	Is factor variable	Mandatory or calculated	ID	% evaluated cases (from cohort)	Rho	Rho_abs	p-value	Rho Male	Rho_abs Male	p-value Male	Rho Female	Rho_abs Female	p-value Female	Max of all abs rho
relative thickness of the walls of the left ventricular	ratio	0	1	RWT	100	0.77	0.77	7.6E-51	0.76	0.76	7.9E-16	0.81	0.81	5.1E-40	0.81
Cardiac Output	L/minute	0	1	LV_CO	100	-0.74	0.74	1.5E-44	-0.71	0.71	2.6E-13	-0.72	0.72	9.1E-29	0.74
ratio peak velocities A and E waves	ratio	0	1	E_A	100	-0.68	0.68	5.6E-35	-0.64	0.64	2.7E-10	-0.73	0.73	1.1E-29	0.73
thickness of interventricular septum	cm	0	1	IVS	100	0.66	0.66	4.2E-32	0.54	0.54	2.4E-07	0.70	0.70	2.5E-26	0.70
posterior wall thickness	cm	0	1	LVPW	100	0.62	0.62	2.0E-27	0.57	0.57	3.4E-08	0.64	0.64	1.8E-20	0.64
end-diastolic volume	ml	0	1	LV_EDV	100	-0.53	0.53	5.4E-19	-0.57	0.57	3.7E-08	-0.51	0.51	1.6E-12	0.57
end-systolic volume	ml	0	1	LV_ESV	100	-0.54	0.54	9.9E-30	-0.53	0.53	5.0E-10	-0.53	0.53	7.7E-20	0.54
end-systolic left ventricular diameter	cm	0	1	LVSD	100	-0.36	0.36	5.1E-09	-0.54	0.54	3.5E-07	-0.35	0.35	3.5E-06	0.54
ejection fraction	%	0	1	LV_EF	100	0.49	0.49	3.5E-16	0.41	0.41	1.7E-04	0.52	0.52	2.4E-13	0.52
aorta diameter	cm	0	1	AO_D	100	0.35	0.35	1.2E-08	0.18	0.18	1.0E-01	0.44	0.44	2.1E-09	0.44
end-diastolic left ventricular diameter	cm	0	1	LVDD	100	-0.22	0.22	5.7E-04	-0.43	0.43	8.6E-05	-0.17	0.17	2.5E-02	0.43
E wave peak	cm/s	0	1	E_P	100	-0.35	0.35	1.3E-08	-0.42	0.42	9.8E-05	-0.36	0.36	1.4E-06	0.42

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fractional shortening	%	0	1	FS	100	0.33	0.33	1.5E-07	0.18	0.18	1.0E-01	0.41	0.41	3.3E-08	0.41
stroke volume	ml	0	1	LV_SV	100	-0.40	0.40	6.8E-11	-0.39	0.39	3.3E-04	-0.39	0.39	2.0E-07	0.40
left atrial volume index	ml/m2	0	1	LAVI	100	0.28	0.28	8.9E-06	0.11	0.11	3.3E-01	0.38	0.38	3.8E-07	0.38
left ventricular mass index	g/m2	0	1	MMI	100	0.23	0.23	2.6E-04	0.26	0.26	2.2E-02	0.26	0.26	5.8E-04	0.26
RWT > 0,42	(0 - no; 1 - yes)	1	1	H_RWT	100	0.75	0.75	2.3E-45	0.70	0.70	1.1E-12	0.78	0.78	1.6E-36	0.78
E/A < 1,0	(0 - no; 1 - yes)	1	1	L_E_A	100	0.62	0.62	1.8E-27	0.57	0.57	3.2E-08	0.67	0.67	3.2E-23	0.67
H_RWT = 1 & H_MMI = 0	(0 - no; 1 - yes)	1	1	CRLV	100	0.55	0.55	7.7E-21	0.48	0.48	8.9E-06	0.57	0.57	4.1E-16	0.57
IVS > 1,1	(0 - no; 1 - yes)	1	1	H_IVS	100	0.40	0.40	6.1E-11	0.40	0.40	2.3E-04	0.49	0.49	1.1E-11	0.49
H_RWT = 1 & H_MMI = 1	(0 - no; 1 - yes)	1	1	CHLV	100	0.33	0.33	1.1E-07	0.37	0.37	9.3E-04	0.34	0.34	4.4E-06	0.37
LAVI > 28	(0 - no; 1 - yes)	1	1	H_LAVI	100	0.20	0.20	2.0E-03	0.05	0.05	6.9E-01	0.32	0.32	2.8E-05	0.32
MMI > 102 male, MMI > 88 female	(0 - no; 1 - yes)	1	1	H_MMI	100	0.21	0.21	9.6E-04	0.20	0.20	8.3E-02	0.23	0.23	2.8E-03	0.23
LVPW > 1,1	(0 - no; 1 - yes)	1	1	H_LVPW	100	0.11	0.11	9.1E-02	0.04	0.04	7.4E-01	0.20	0.20	9.7E-03	0.20
H_RWT = 0 & H_MMI = 1	(0 - no; 1 - yes)	1	1	ERLV	100	-0.09	0.09	1.5E-01	-0.17	0.17	1.4E-01	-0.07	0.07	3.4E-01	0.17
AO_D > 3,8	(0 - no; 1 - yes)	1	1	H_AO_D	100	0.06	0.06	3.3E-01	0.08	0.08	5.1E-01	0.13	0.13	1.1E-01	0.13
Calcium index	ratio	0	0	CAIND	4	0.74	0.74	5.4E-02				0.85	0.85	5.4E-02	0.85

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Isovolumic relaxation time	millisecond	0	0	IVRT	100	0.68	0.68	1.5E-35	0.66	0.66	3.1E-11	0.74	0.74	4.5E-30	0.74
Pulm S/D	ratio	0	0	S_D	100	0.72	0.72	7.4E-41	0.67	0.67	2.3E-11	0.69	0.69	4.2E-25	0.72
E'/A' lateral	ratio	0	0	E1_A1	100	-0.67	0.67	4.2E-34	-0.68	0.68	4.0E-12	-0.71	0.71	6.0E-27	0.71
E' lateral	cm/s	0	0	E1	100	-0.60	0.60	3.7E-25	-0.60	0.60	3.8E-09	-0.64	0.64	8.2E-21	0.64
Deceleration time	millisecond	0	0	DT	100	0.52	0.52	1.8E-18	0.48	0.48	6.7E-06	0.59	0.59	6.3E-17	0.59
A wave peak	cm/s	0	0	A_P	100	0.52	0.52	7.1E-19	0.45	0.45	2.7E-05	0.55	0.55	1.2E-14	0.55
A reversal duration	millisecond	0	0	ARD	100	0.44	0.44	2.6E-13	0.50	0.50	3.2E-06	0.48	0.48	6.4E-11	0.50
A reversal velocity	cm/s	0	0	ARV	100	0.41	0.41	1.5E-11	0.35	0.35	1.7E-03	0.47	0.47	1.4E-10	0.47
E/E' lateral	ratio	0	0	E_E1	100	0.41	0.41	3.2E-11	0.37	0.37	8.3E-04	0.42	0.42	1.1E-08	0.42
S' lateral	cm/s	0	0	S1	100	-0.35	0.35	1.1E-08	-0.25	0.25	2.4E-02	-0.39	0.39	1.3E-07	0.39
A' lateral	cm/s	0	0	A1	100	0.31	0.31	4.4E-07	0.20	0.20	7.1E-02	0.36	0.36	1.8E-06	0.36
S/D > 1	(0 - no; 1 - yes)	1	0	H_S_D	100	0.68	0.68	1.8E-34	0.66	0.66	4.1E-11	0.65	0.65	2.6E-21	0.68
L_E_A = 1 or L_E1_A1 = 1	(0 - no; 1 - yes)	1	0	DD_LV	100	0.62	0.62	3.0E-27	0.57	0.57	5.4E-08	0.67	0.67	4.9E-23	0.67
E'/A' < 1	(0 - no; 1 - yes)	1	0	L_E1_A1	100	0.59	0.59	6.5E-25	0.56	0.56	7.3E-08	0.64	0.64	9.2E-21	0.64
IVRT > 90	(0 - no; 1 - yes)	1	0	H_IVRT	100	0.55	0.55	1.3E-20	0.49	0.49	4.7E-06	0.60	0.60	3.3E-18	0.60

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DT > 220	(0 - no; 1 - yes)	1	0	H_DT	100	0.42	0.42	5.2E-12	0.47	0.47	1.0E-05	0.44	0.44	2.0E-09	0.47
E1 < 8	(0 - no; 1 - yes)	1	0	L_E1	100	0.36	0.36	5.2E-09	0.36	0.36	1.0E-03	0.39	0.39	1.2E-07	0.39
ARV > 35	(0 - no; 1 - yes)	1	0	H_ARV	100	0.28	0.28	6.5E-06	0.19	0.19	9.3E-02	0.36	0.36	1.8E-06	0.36

Supplementary Table 2. Quality indicators of models.

		train rates				test rates				mean rates				scales mean rates				score
model №	predictors	mse	mae	mape	rmse	mse	mae	mape	rmse	mse	mae	mape	rmse	mse	mae	mape	rmse	
1	LVCO_EA_RWT_IVS	49.79	5.41	12.03	7.06	44.65	5.31	11.85	6.68	47.22	5.36	11.94	6.87	0.225	0.257	0.197	0.214	0.894
2	LVCO_EA_RWT_LVPW	41.91	5.14	11.37	6.47	46.21	5.59	12.25	6.80	44.06	5.36	11.81	6.64	0.277	0.256	0.206	0.241	0.980
3	LVCO_EA_IVS_LVPW	59.39	6.11	13.95	7.71	60.52	6.30	13.80	7.78	59.96	6.21	13.87	7.74	0.016	0.139	0.067	0.114	0.337
4	LVCO_RWT_IVS_LVPW	49.94	5.60	12.55	7.07	51.25	5.58	12.53	7.16	50.59	5.59	12.54	7.11	0.170	0.224	0.157	0.186	0.738
5	EA_RWT_IVS_LVPW	59.72	6.25	14.14	7.73	47.66	5.37	11.38	6.90	53.69	5.81	12.76	7.32	0.119	0.194	0.142	0.163	0.619
6	LVCO_EA_RWT_IVS_LVPW	37.69	4.86	10.59	6.14	50.09	5.72	12.42	7.08	43.89	5.29	11.51	6.61	0.280	0.266	0.226	0.244	1.017
									max	60.96	7.21	14.87	8.74					

Supplementary Table 3. Frequency analysis of conditions.

1 – Cardio

ID	Age group	Chi-squared p-value			Frequency difference		Cohorts
		across 3 delta groups	PosΔ10 vs NegΔ10	PosΔ10 vs NeutralΔ	PosΔ10 vs NegΔ10	PosΔ10 vs NeutralΔ	
I10-I15	41-50	0.01583	0.03243	0.00612	0.15	0.14	BD
I10-I15	51-60	0.00008	0.00003	0.00015	0.29	0.24	BD
I10-I15	61-70	NA	NA	0.01562	NA	0.41	AC
I20-I25	41-50	NA	NA	0.01389	NA	0.40	AC
I20-I25	51-60	NA	NA	0.02938	NA	0.85	AC
I20-I25	61-70	NA	NA	0.00529	NA	0.44	AC
I20-I25	61-70	0.04744	0.04977	0.03024	0.11	0.11	BD
I44-I45	41-50	NA	NA	0.01389	NA	0.40	AC
I44-I45	51-60	NA	NA	0.02938	NA	0.85	AC
I44-I45	51-60	0.00003	0.00023	0.00005	0.14	0.13	BD

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I49.4	41-50	NA	NA	0.01389	NA	0.40	AC
I49.4	51-60	NA	NA	0.02938	NA	0.85	AC
I49.4	61-70	NA	NA	0.00291	NA	0.50	AC
I67	41-50	NA	NA	0.01389	NA	0.40	AC
I67	51-60	NA	NA	0.02938	NA	0.85	AC
I67	61-70	NA	NA	0.00529	NA	0.44	AC
I67	71-80	NA	NA	0.00616	NA	0.42	AC

2 - Endocr., Metabol., Digest.

		Chi-squared p-value			Frequency difference		
ID	Age group	across 3 delta groups	PosΔ10 vs NegΔ10	PosΔ10 vs NeutralΔ	PosΔ10 vs NegΔ10	PosΔ10 vs NeutralΔ	Cohorts
E00-E07	18-30	0.08935	0.87600	0.06241	0.31	0.14	BD
E10-E14	41-50	NA	NA	0.01389	NA	0.40	AC
E10-E14	51-60	NA	NA	0.02938	NA	0.85	AC
E55	51-60	0.01720	0.01031	0.11223	0.17	0.10	BD
E55	61-70	0.01297	0.36127	0.03085	0.08	0.17	BD
E66	18-30	0.07199	0.95701	0.04756	0.27	0.13	BD
E66	31-40	0.03685	0.30410	0.01507	0.11	0.10	BD
E66	41-50	0.09642	0.07453	0.59468	0.12	0.03	BD
E66	51-60	0.00726	0.00266	0.01241	0.20	0.16	BD
E66	61-70	0.01697	0.02346	0.23356	0.19	0.10	BD
K76	51-60	0.11114	0.05531	0.06331	0.14	0.12	BD
K76	61-70	0.13436	0.06501	0.11067	0.16	0.14	BD
K80	61-70	0.00397	0.00306	0.00360	0.19	0.17	BD

3 – Children

		Chi-squared p-value			Frequency difference		
ID	Age group	across 3 delta groups	PosΔ10 vs NegΔ10	PosΔ10 vs NeutralΔ	PosΔ10 vs NegΔ10	PosΔ10 vs NeutralΔ	Cohorts
L20-L30	<18	NA	NA	0.07493	NA	0.15	BD
Q20	<18	NA	NA	0.06611	NA	0.17	BD

4 - Multimorbid.

		Chi-squared p-value			Frequency difference		
ID	Age group	across 3 delta groups	PosΔ10 vs NegΔ10	PosΔ10 vs NeutralΔ	PosΔ10 vs NegΔ10	PosΔ10 vs NeutralΔ	Cohorts
n2	18-30	0.00106	0.53451	0.00071	0.48	0.26	BD
n2	31-40	0.02172	0.01838	0.07339	0.24	0.08	BD
n2	41-50	NA	NA	0.01389	NA	0.40	AC
n2	51-60	NA	NA	0.02938	NA	0.85	AC
n2	51-60	0.00671	0.00260	0.01104	0.19	0.15	BD
n2	61-70	NA	NA	0.00000	NA	0.80	AC
n2	61-70	0.05312	0.02813	0.03030	0.14	0.13	BD

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n2	71-80	NA	NA	0.02209	NA	0.45	AC
n3	41-50	NA	NA	0.01389	NA	0.40	AC
n3	51-60	NA	NA	0.02938	NA	0.85	AC
n3	51-60	0.01727	0.01014	0.09454	0.18	0.11	BD
n3	61-70	NA	NA	0.03461	NA	0.34	AC
n3	61-70	0.03613	0.01569	0.03167	0.20	0.17	BD
n3	71-80	NA	NA	0.03906	NA	0.38	AC
n4	41-50	NA	NA	0.01389	NA	0.40	AC
n4	51-60	NA	NA	0.02938	NA	0.85	AC
n4	51-60	0.01941	0.00836	0.06264	0.15	0.10	BD
n4	61-70	0.00169	0.00181	0.00077	0.25	0.25	BD