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Left ventricular motion quantification parameters from tissue phase mapped MRI: influence of gender

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Background

Several motion parameters for quantification of LV motion abnormalities and asynchrony have been described in literature, but were investigated with different acquisition protocols and for different cohorts, thus impeding comparability. For derivation of normal values in healthy volunteers, calculation of all parameters from a single acquisition protocol is desirable. In this study, influence of gender on the motion parameters is investigated in order to determine the necessity of separate female/male normal values.

Methods

Cohorts and acquisition

20 females (27.3±6.6 y) and 21 males (23.6±2.1 y) without known cardiovascular diseases were investigated. Acquisition parameters were: Philips Achieva 3 T, 32 channel cardiac coil, velocity encoded (Tissue Phase Mapped, TPM) segmented black-blood gradient echo with VENC=30 cm/s, TR/TE=6.1/4.6 ms, FOV adapted to patient size, resolution = 2x2x8 mm^3, 3 k-lines/segment, SENSE=2, phase interval=30 ms, and nominal scan time=5:51 min:sec for 3 short axis slices.

Motion-Quantification parameters (see [1])

The following parameters were calculated:

a) velocity-based: Standard Deviation of Times to Peak [σ(TTP)], Asynchrony Correlation Coefficient [ACC], Temporal Uniformity of Velocity [TUV], and difference of peak velocities [Δv].

b) rotation-based: Base Apex Rotation Correlation [BARC].

c) strain-based: Temporal Uniformity of Strain [TUS], Standard Deviation of Onset/Peak Time [$\sigma(T_{onset/peak})$], Coefficient of Variation [CV], Difference between Septal and Lateral Peak Circumferential Strain [DiffSLpeakCS], Onset/Peak Of Shortening Delay [OS/PS Delay], Regional Variance of Strain [RVS], and Regional Variance Vector of Strain [RVVPS].

Analysis

Difference of these parameters between the female and male group was assessed by a non-parametric Wilcoxon rank-sum test and p-values below 5% were considered significant.

Results

Significant differences were found for peak velocities v^l_{max} and v^c_{min} in all slices and $v^c_{basal,max}$, $v^r_{apical,max}$, $v^r_{basal,max}$ in individual slices, as well as the peak velocity differences $\Delta v^c_{equatorial}$ and Δv^c_{basal}, and $\sigma(TTP)^r_{sys}$. The rotation-based parameter BARC showed also significant differences. All other differences were not statistically significant (see Figures 1 and 2).

Conclusions

While peak velocities and their difference Δv as well as BARC require separate consideration for males and females, all velocity and strain based asynchrony parameters except $\sigma(TTP)^r_{sys}$ show no dependence of gender and thus appear suitable to calculate normal values from a mixed female/male healthy volunteer cohort.

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Parameter	p-value	female			male		
		p_{25}	p_{50}	p_{75}	p_{25}	p_{50}	p_{25}
TTP^{r}_{sys}	0,268 NS	96,58	104,54	114,63	103,10	107,28	112,21
TTP^{r}_{dia}	0,268 NS	461,12	476,37	508,32	452,64	467,29	480,87
$\sigma(TTP)^{r}_{sys}$	0,049 *	28,16	31,93	33,90	32,12	34,23	38,48
$\sigma(TTP)^{r}_{dia}$	0,804 NS	31,09	38,23	42,62	28,10	37,57	49,39
TTP^{l}_{sys}	0,557 NS	65,73	73,77	81,44	67,44	71,65	75,72
TTP^{l}_{dia}	0,489 NS	448,62	470,70	492,20	450,26	464,78	473,26
$\sigma(TTP)^{l}_{sys}$	0,744 NS	5,35	8,68	27,37	6,39	9,55	12,98
$\sigma(TTP)^{l}_{dia}$	0,990 NS	10,56	14,50	18,95	11,93	14,39	17,43
ACC^{r}_{min}	0,907 NS	0,14	0,29	0,42	0,15	0,24	0,44
ACC^{r}_{mean}	0,442 NS	0,73	0,76	0,80	0,71	0,74	0,79
ACC^{r}_{max}	0,886 NS	0,95	0,96	0,97	0,96	0,96	0,97
ACC^{c}_{min}	0,179 NS	0,14	0,19	0,25	-0,01	0,12	0,24
ACC^{c}_{mean}	0,328 NS	0,64	0,66	0,74	0,66	0,70	0,75
ACC^{c}_{max}	0,948 NS	0,92	0,94	0,95	0,93	0,94	0,95
ACC^{l}_{min}	0,442 NS	0,09	0,53	0,70	0,37	0,58	0,68
ACC^{l}_{mean}	0,825 NS	0,84	0,91	0,93	0,88	0,90	0,93
ACC^{l}_{max}	0,328 NS	0,98	0,98	0,99	0,98	0,99	0,99
TUV^{r}	0,368 NS	0,78	0,79	0,80	0,77	0,79	0,80
TUV^{c}	0,629 NS	0,74	0,76	0,78	0,75	0,76	0,79
TUV^{l}	0,235 NS	0,84	0,86	0,88	0,83	0,85	0,86
$v^{l}_{apical,min}$	0,246 NS	-5,84	-4,95	-3,22	-6,08	-5,19	-4,09
$v^{l}_{equatorial,min}$	0,557 NS	-10,35	-9,70	-7,49	-10,94	-8,11	-7,13
$v^{l}_{basal,min}$	0,246 NS	-14,40	-13,62	-11,70	-14,24	-12,41	-11,49
$v^{l}_{apical,max}$	0,024 *	3,43	3,81	4,49	3,98	4,43	5,48
$v^{l}_{equatorial,max}$	0,007 **	4,15	5,58	6,50	5,66	6,61	7,70
$v^{l}_{basal,max}$	0,006 **	5,86	7,13	7,66	7,08	8,34	9,63
Δv^{l}_{apical}	0,078 NS	7,19	8,17	10,32	8,65	9,28	11,04
$\Delta v^{l}_{equatorial}$	0,540 NS	11,68	14,99	16,68	13,42	14,47	17,58
Δv^{l}_{basal}	0,557 NS	18,74	20,72	21,91	19,02	20,09	22,80

Figure 1 P-values and significances for comparison of the female vs. male group for the different motion quantification parameters. Also shown are lower (p_{25}) and upper quartile (p_{75}) and the median (p_{50}). Abbreviations: r = radial, c = circumferential, l = longitudinal; ***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$, NS: $p >= 0.05$.

Parameter	p-value	female			male		
		p_{25}	p_{50}	p_{75}	p_{25}	p_{50}	p_{25}
$v^c_{apical,min}$	0,010 *	-4,35	-3,33	-2,75	-5,30	-4,53	-3,83
$v^c_{equatorial,min}$	0,005 **	-4,37	-3,54	-3,28	-5,41	-4,92	-4,19
$v^c_{basal,min}$	0,016 *	-4,13	-3,31	-2,97	-4,75	-4,08	-3,61
$v^c_{apical,max}$	0,784 NS	2,16	2,65	2,95	2,01	2,59	3,00
$v^c_{equatorial,max}$	0,103 NS	1,86	2,19	2,52	2,17	2,44	2,80
$v^c_{basal,max}$	0,000 ***	2,05	2,30	2,68	3,14	3,40	3,84
Δv^c_{apical}	0,078 NS	5,31	6,20	7,43	6,33	6,91	8,15
$\Delta v^c_{equatorial}$	0,002 **	5,27	6,02	6,45	6,80	7,50	8,23
Δv^c_{basal}	0,000 ***	5,16	5,97	6,39	7,16	7,59	7,99
$v^r_{apical,min}$	0,593 NS	-5,96	-5,09	-4,46	-5,83	-5,37	-4,65
$v^r_{equatorial,min}$	0,648 NS	-5,93	-5,54	-4,82	-5,90	-5,59	-5,17
$v^r_{basal,min}$	0,197 NS	-5,49	-4,62	-4,12	-5,71	-5,05	-4,86
$v^r_{apical,max}$	0,000 ***	1,91	2,17	2,50	2,47	2,64	2,81
$v^r_{equatorial,max}$	0,188 NS	2,55	3,02	3,36	2,88	3,16	3,49
$v^r_{basal,max}$	0,017 *	2,49	2,99	3,16	2,95	3,24	3,50
Δv^r_{apical}	0,115 NS	6,49	7,44	8,45	7,34	8,00	8,69
$\Delta v^r_{equatorial}$	0,368 NS	7,65	8,45	9,08	7,97	8,86	9,36
Δv^r_{basal}	0,098 NS	7,11	7,50	8,61	7,63	8,57	9,01
BARC	0,002 **	-0,42	-0,11	0,07	-0,05	0,26	0,42
TUS^c	0,948 NS	0,87	0,89	0,92	0,87	0,91	0,93
TUS^r	0,206 NS	0,82	0,88	0,90	0,86	0,88	0,92
RVS	0,744 NS	41,64	55,31	94,94	34,60	52,34	100,70
RVVPS	0,523 NS	64,67	86,13	102,14	64,21	69,82	97,85
$\sigma(T_{onset})$	0,171 NS	9,54	10,69	12,48	9,58	11,65	14,77
$\sigma(T_{peak})$	0,886 NS	33,82	38,95	45,82	31,34	35,69	48,51
CV	0,804 NS	22,85	26,69	30,44	20,15	24,84	34,64
DiffSLpeakCS	0,705 NS	-2,96	-0,37	1,32	-3,09	-1,27	1,05
OS delay SL	0,509 NS	0,00	0,00	0,00	0,00	0,00	0,25
OS delay IA	0,792 NS	0,00	0,00	0,00	0,00	0,00	0,00
OS delay AB	0,323 NS	0,00	0,00	0,00	0,00	0,00	0,00
PS delay SL	0,927 NS	17,00	26,00	47,00	12,75	26,00	59,50
PS delay IA	0,724 NS	3,50	6,50	20,50	4,00	9,00	18,50
PS delay AB	0,124 NS	17,00	52,50	74,50	7,75	15,00	75,75

Figure 2 (continued from Figure 1). Abbreviations: SL = septal-lateral, IA = inferior-anterior, AB = apical-basal.

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