

# Elevated myocardial wall stress in children is associated with impaired cardiac growth at younger age

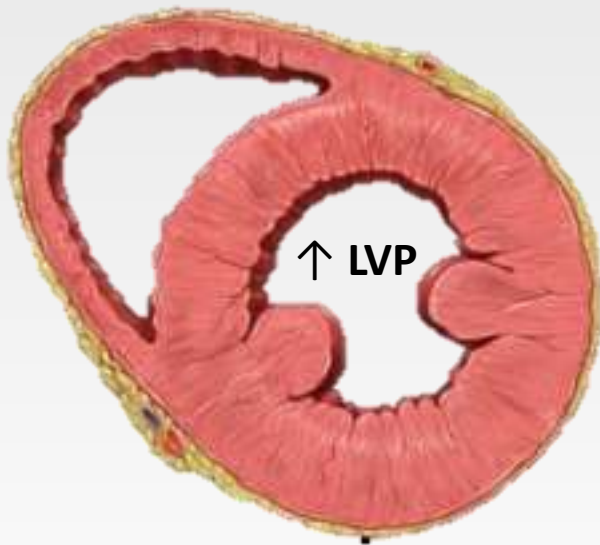
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# Myocardial wall stress and LV remodelling in adults

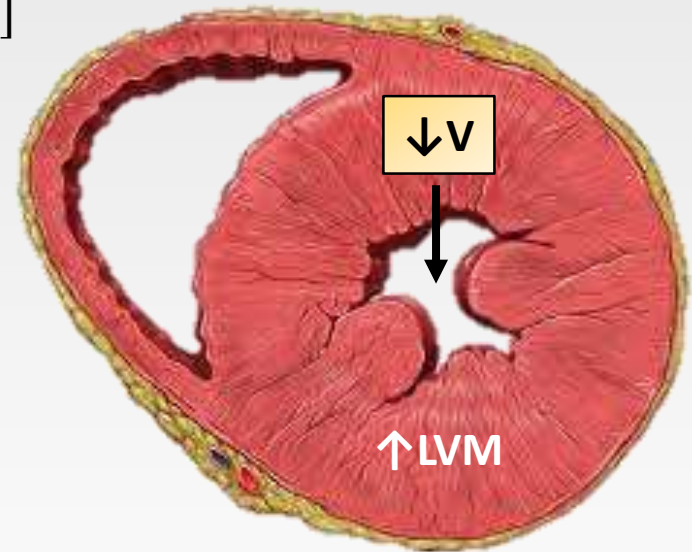
Normal



↑LV mass (LVM) and/or  
 ↓Volume (V) help offset  
 the effects of ↑LVP pressure

$$MWS = \frac{(\text{LVP}) \text{ on MWS}}{\left[ \frac{1}{3} \ln \left( 1 + \frac{LVM}{\text{Volume}} \right) \right]}$$

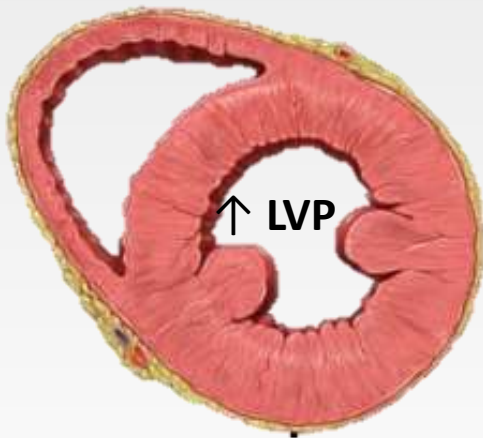
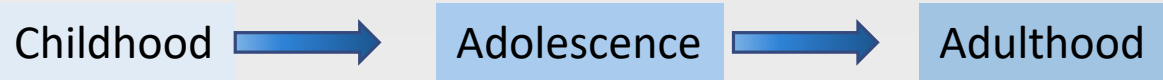
Concentric Hypertrophy



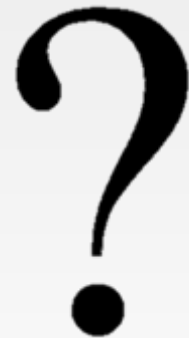
# LV remodelling in Children

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When the heart is still growing



↑MWS



# Aim

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To examine how MWS relates to LV remodelling in children and adolescents - a longitudinal study

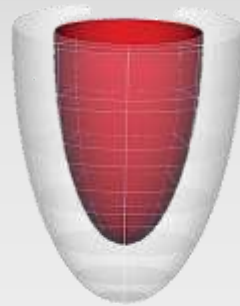
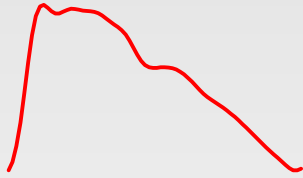
Wall Volume

# Myocardial wall stress

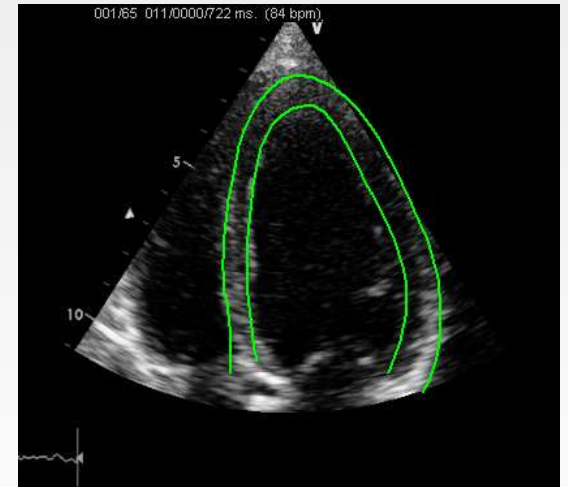
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LV Pressure

LV Geometry



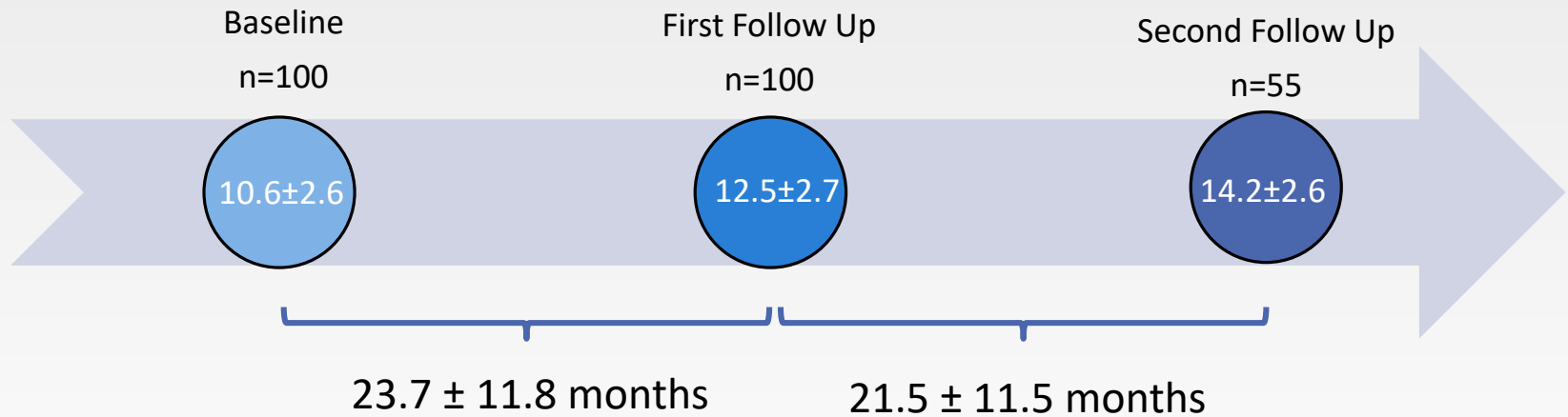
Cavity Volume



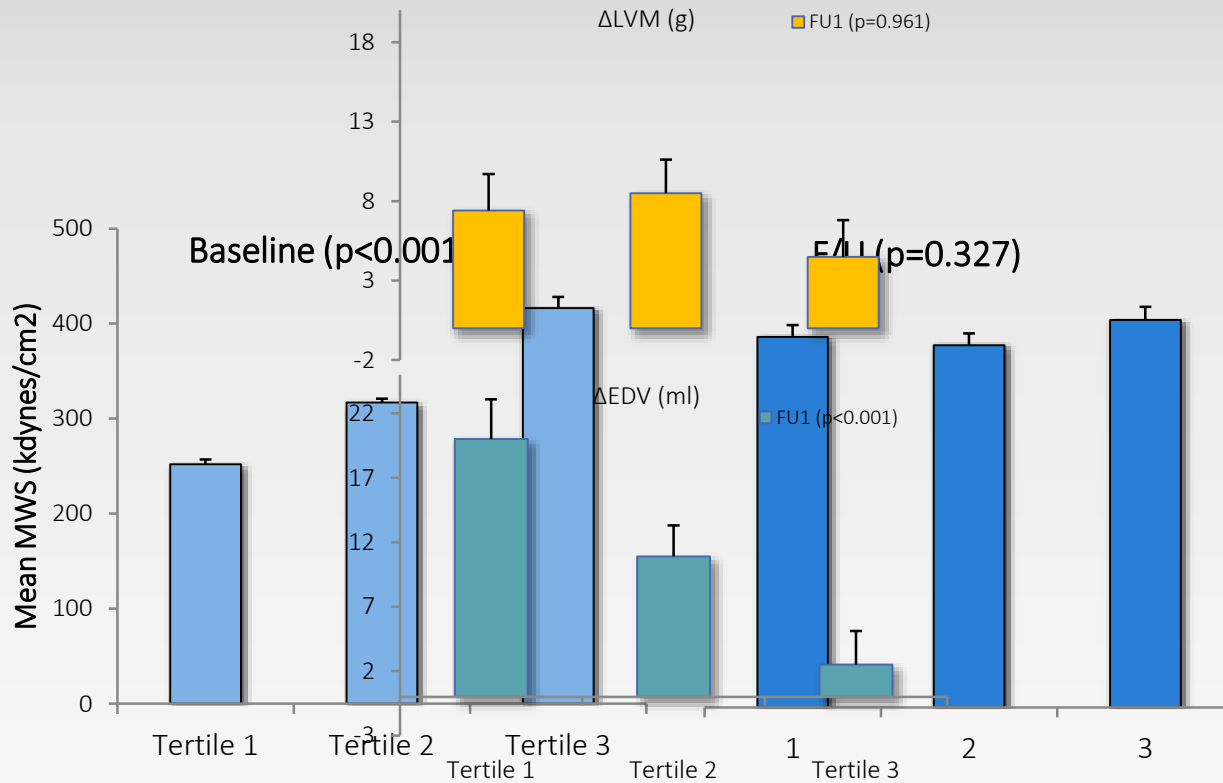
# Study Design

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- 100 children - 34 controls and 66 CKD



# MWS, LVM and LV Volume between baseline and first FU

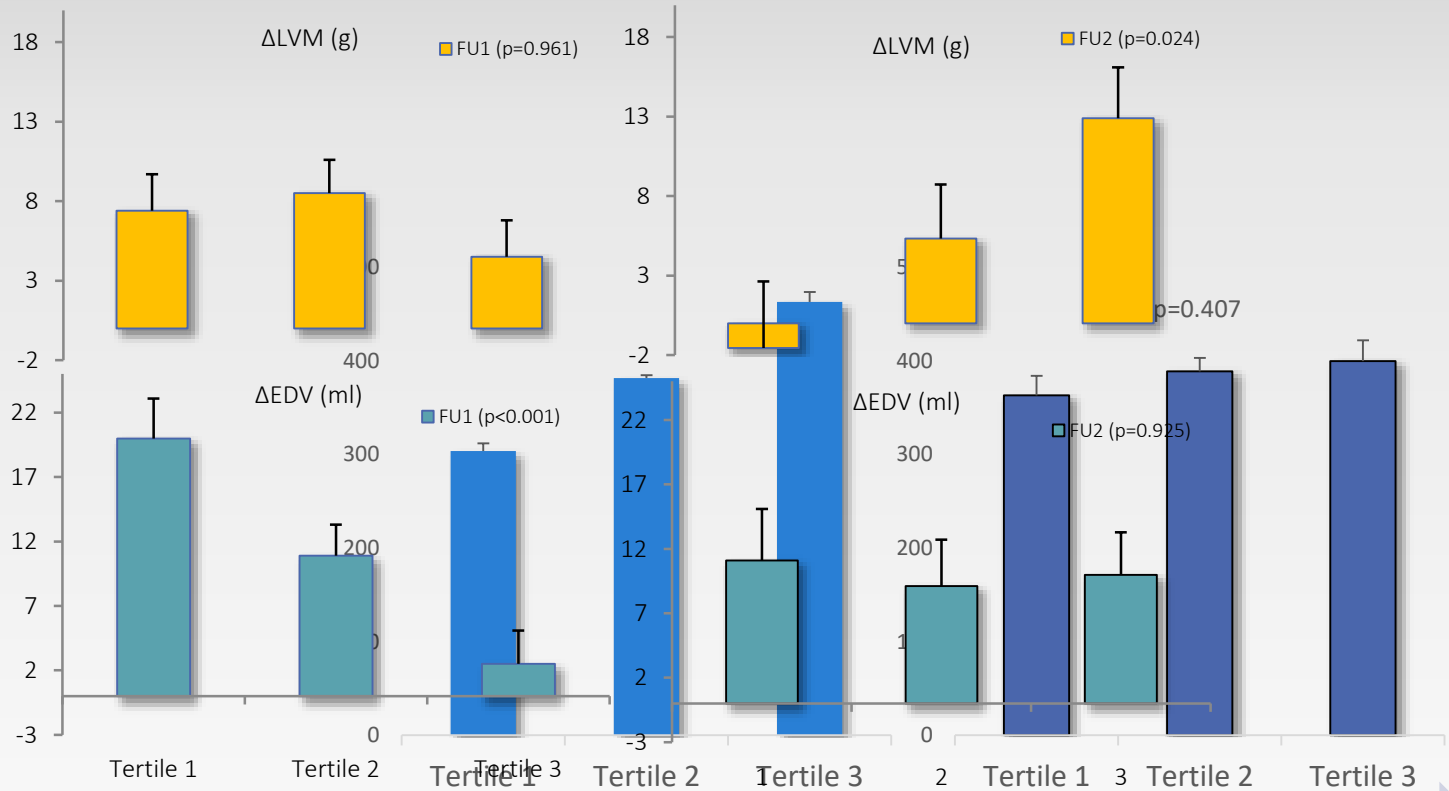


10.6±2.6

12.5±2.7

14.2±2.6

# MWS, LVM and LV Volume between first and second FU



10.6±2.6

12.5±2.7

14.2±2.6



# Multiple linear regression

| Covariate             | Δ LVM (g)<br>(r <sup>2</sup> =0.177) |              | Δ EDV (ml)<br>(r <sup>2</sup> =0.560) |                  | Δ LVM (g)<br>(r <sup>2</sup> =0.254) |              | Δ EDV (ml)<br>(r <sup>2</sup> =0.560) |              |
|-----------------------|--------------------------------------|--------------|---------------------------------------|------------------|--------------------------------------|--------------|---------------------------------------|--------------|
|                       | β                                    | P Value      | β                                     | P Value          | β                                    | P Value      | β                                     | P Value      |
| Age (years)           | -0.304                               | 0.160        | -0.355                                | 0.056            | -0.210                               | 0.272        | -0.348                                | 0.133        |
| Gender                | 0.038                                | 0.702        | -0.262                                | <b>0.002</b>     | -0.214                               | 0.166        | -0.089                                | 0.638        |
| BSA (m <sup>2</sup> ) | 0.592                                | <b>0.028</b> | 0.853                                 | <b>0.001</b>     | 0.756                                | <b>0.010</b> | 0.519                                 | 0.126        |
| HR (bpm)              | 0.126                                | 0.277        | 0.019                                 | 0.853            | 0.017                                | 0.907        | -0.130                                | 0.416        |
| MAP(mmHg)             | 0.184                                | 0.131        | 0.003                                 | 0.979            | 0.077                                | 0.664        | -0.007                                | 0.971        |
| LVM (g)               | -0.362                               | <b>0.049</b> | –                                     | –                | -0.586                               | <b>0.004</b> | –                                     | –            |
| EDV (ml)              | –                                    | –            | -0.793                                | <b>&lt;0.001</b> | –                                    | –            | -0.476                                | <b>0.034</b> |
| FU Length             | 0.170                                | 0.108        | 0.216                                 | <b>0.014</b>     | 0.249                                | 0.096        | 0.079                                 | 0.661        |
| Medication            | 0.141                                | 0.170        | 0.125                                 | 0.143            | 0.006                                | 0.966        | 0.018                                 | 0.913        |
| <b>MWS</b>            | -0.187                               | 0.120        | <b>-0.237</b>                         | <b>0.030</b>     | <b>0.355</b>                         | <b>0.021</b> | 0.140                                 | 0.434        |

10.6±2.6

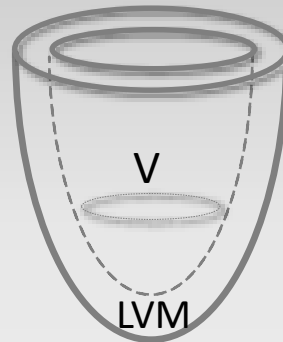
12.5±2.7

14.2±2.6

# Conclusions

Younger Children

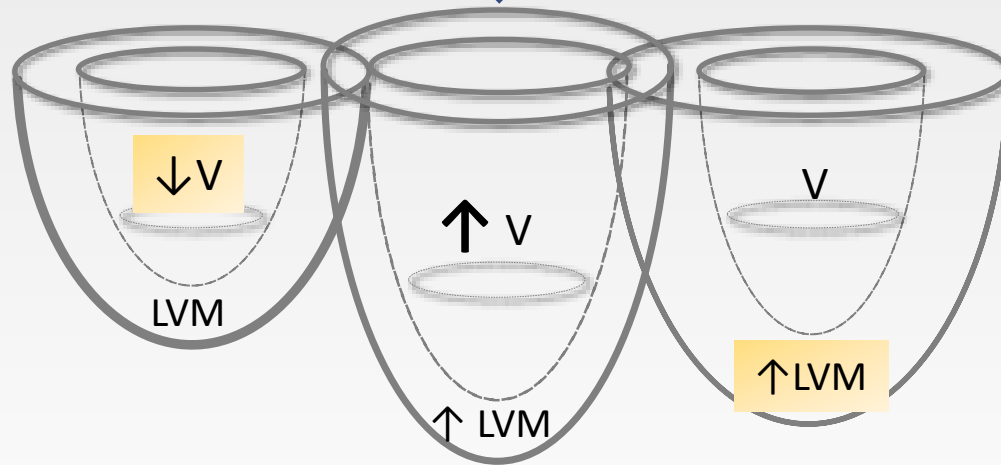
Pathological remodelling:  
impaired longitudinal  
ventricular growth



Adolescents

Pathological remodelling:  
increased LVM in keeping with  
adult remodelling pattern.

Physiological remodelling  $\uparrow$  MYS



Thank you

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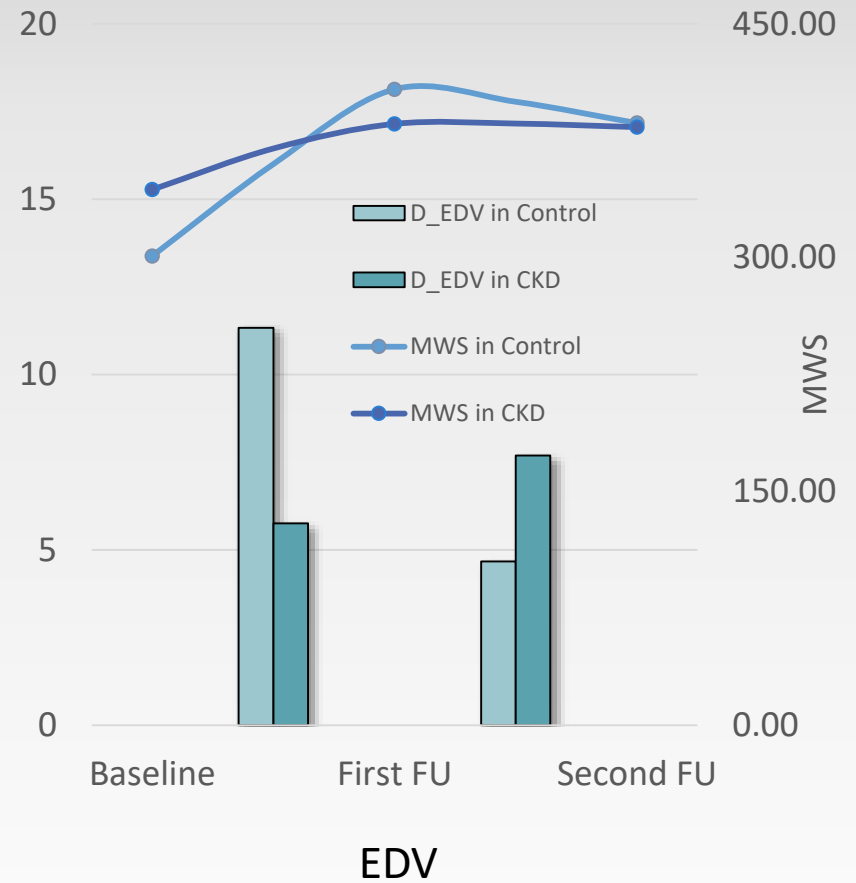
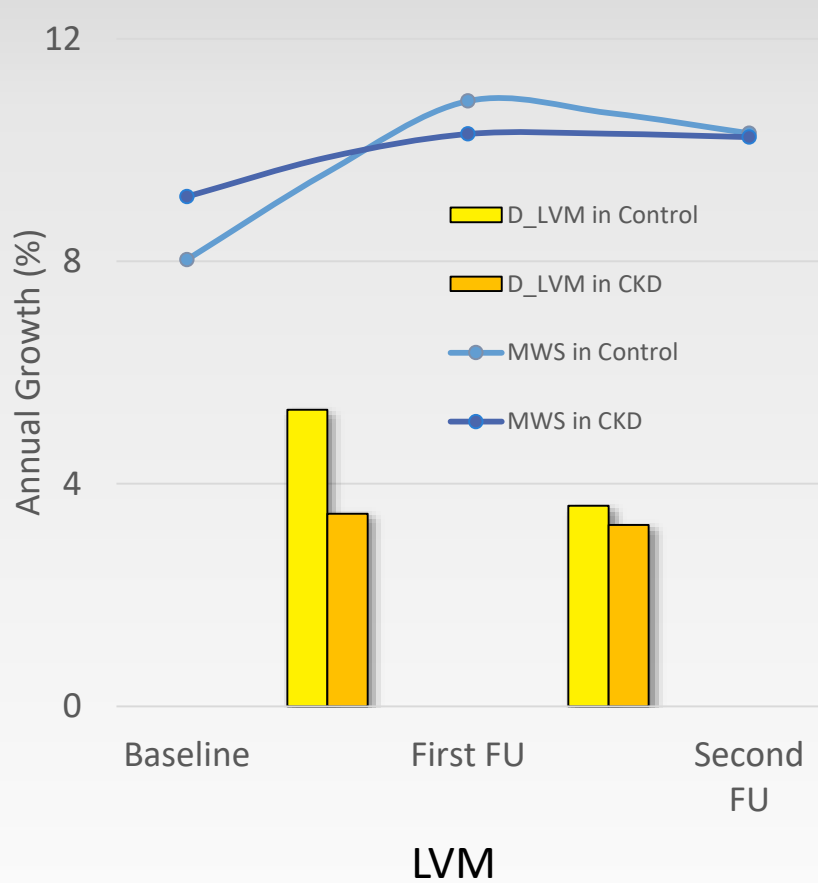
# Subject Characteristics and BPs at baseline and first follow up visit

| Measures                              | Control (n=34) |           |            |        | CKD (n=66) |            |            |        |
|---------------------------------------|----------------|-----------|------------|--------|------------|------------|------------|--------|
|                                       | Baseline       | Follow Up | Difference | P diff | Baseline   | Follow Up  | Difference | P diff |
| Age (Y)                               | 10.5±3.2       | 12.9±3.1  | 2.4±0.9    | <0.001 | 10.7±3.0   | 12.6±3.1   | 1.9±0.9    | <0.001 |
| Height (m)                            | 1.44±0.22      | 1.55±0.17 | 0.11±0.10  | <0.001 | 1.43±0.18  | 1.52±0.16  | 0.09±0.06  | <0.001 |
| Weight (kg)                           | 42.7±19.6      | 52.6±17.0 | 9.9±9.5    | <0.001 | 39.6±15.1  | 47.0±16.3  | 7.4±5.9    | <0.001 |
| BMI z-score                           | 0.57±1.0       | 0.66±1.0  | 0.09±0.4   | ns     | 0.28±1.1   | 0.28±1.2   | 0.0±0.6    | ns     |
| Heart rate (bpm)                      | 80.1±13.8      | 76.2±12.1 | -4.0±13.9  | ns     | 80.4±14.1  | 75.5±10.6  | -4.5±12.2  | 0.008  |
| SBP (mmHg)                            | 101±12         | 109±11    | 8±11       | 0.004  | 99±11      | 105±10     | 6±10       | <0.001 |
| DBP (mmHg)                            | 54±10          | 66±9      | 10±11      | <0.001 | 53±10      | 61±13      | 8±14       | <0.001 |
| SBP z-score                           | -0.24±0.85     | 0.04±1.0  | 0.29±1.1   | ns     | -0.42±0.85 | -0.16±0.85 | 0.26±0.91  | 0.034  |
| DBP z-score                           | -0.63±0.8      | 0.17±0.7  | 0.80±1.0   | <0.001 | -0.71±0.80 | -0.13±1.05 | 0.58±1.27  | 0.001  |
| MAP (mmHg)                            | 70±8           | 79±8      | 9±9        | <0.001 | 69±8       | 77±10      | 8±11       | <0.001 |
| cSBP (mmHg)                           | 86±9           | 93±10     | 7±11       | 0.005  | 84±10      | 91±10      | 7±12       | <0.001 |
| eGFR (ml/min per 1.73m <sup>2</sup> ) | —              | —         | —          | —      | 73.7±4.2   | 58.0±3.4   | -15.7±1.8  | <0.001 |
| Anti-hypertensive (n,%)               | —              | —         | —          | —      | 17, 30.4   | 21, 37.5   | —          | —      |

# LV geometry, function and MWS

| Measures                    | Control (n=34) |                        |            |        | CKD (n=66)  |                        |            |        |
|-----------------------------|----------------|------------------------|------------|--------|-------------|------------------------|------------|--------|
|                             | Baseline       | Follow Up              | Difference | P diff | Baseline    | Follow Up              | Difference | P diff |
| EDV (ml)                    | 70.6±28.5      | 85.8±23.9              | 15.1±17.0  | <0.001 | 71.4±24.7   | 79.2±23.3              | 7.9±20.3   | 0.005  |
| ESV (ml)                    | 31.5±2.8       | 36.7±2.3               | 5.2±1.6    | 0.003  | 32.1±1.5    | 34.2±1.4               | 2.1±1.3    | ns     |
| LVM (g)                     | 76.9±26.8      | 87.2±24.9              | 9.3±8.2    | <0.001 | 79.1±23.3   | 85.2±28.2              | 6.2±13.0   | 0.001  |
| LVM z-score                 | -1.45±1.3      | -1.80±1.3              | -0.34±0.9  | ns     | -0.93±1.3   | -1.6±1.3               | -0.67±1.1  | <0.001 |
| LVM I (g/m <sup>2.7</sup> ) | 28.9±7.0       | 26.4±5.6               | -2.6±5.8   | 0.048  | 30.3±6.6    | 27.3±5.8               | -3.0±4.6   | <0.001 |
| RWT                         | 0.32±0.01      | 0.31±0.01 <sup>#</sup> | -0.02±0.01 | ns     | 0.32±0.01   | 0.34±0.01 <sup>#</sup> | 0.01±0.01  | ns     |
| LVM/EDV (g/ml)              | 1.13±0.25      | 1.01±0.18              | -0.11±0.26 | 0.046  | 1.14±0.24   | 1.09±0.24              | -0.05±0.31 | ns     |
| EF (%)                      | 55.1±1.3       | 57.3±0.8               | 2.2±1.3    | ns     | 54.8±0.7    | 56.7±0.7               | 1.8±0.9    | 0.039  |
| GLS (%)                     | -20.0±0.7      | -18.1±0.7              | 1.4±0.8    | ns     | -19.7±0.4   | -18.1±0.4              | 1.3±0.6    | ns     |
| E/E'                        | 5.4±0.2        | 5.4±0.2                | 0.01±0.3   | ns     | 5.7±0.2     | 5.8±0.2                | 0.06±0.2   | ns     |
| Mean MWS                    | 281.2±10.0*    | 399.6±16.1             | 118.4±18.3 | <0.001 | 313.9±8.3*  | 390.8±10.8             | 76.9±12.2  | <0.001 |
| Peak MWS                    | 342.5±14.1*    | 467.5±18.4             | 124.9±21.9 | <0.001 | 386.4±10.8* | 458.6±11.9             | 72.2±14.6  | <0.001 |
| ES MWS                      | 211.3±7.3*     | 318.5±14.7             | 107.2±16.1 | <0.001 | 234.0±6.6*  | 312.7±10.2             | 78.6±10.7  | <0.001 |

# Control VS CKD



# Multiple Linear Regression between baseline and first follow up

| Covariate         | $\Delta$ LVM (g)<br>( $r^2=0.177$ ) |         | $\Delta$ EDV (ml)<br>( $r^2=0.560$ ) |              |
|-------------------|-------------------------------------|---------|--------------------------------------|--------------|
|                   | $\beta$                             | P Value | $\beta$                              | P Value      |
| Age (years)       | -0.304                              | 0.160   | -0.355                               | 0.056        |
| Gender            | 0.038                               | 0.702   | -0.262                               | 0.002        |
| BSA (m2)          | 0.592                               | 0.028   | 0.853                                | 0.001        |
| HR (bpm)          | 0.126                               | 0.277   | 0.019                                | 0.853        |
| MAP (mmHg)        | 0.184                               | 0.131   | 0.003                                | 0.979        |
| LVM (g)           | -0.362                              | 0.049   | –                                    | –            |
| EDV (ml)          | –                                   | –       | -0.793                               | <0.001       |
| FU Length         | 0.170                               | 0.108   | 0.216                                | 0.014        |
| Anti-hypertensive | 0.141                               | 0.170   | 0.125                                | 0.143        |
| Baseline Mean MWS | -0.187                              | 0.120   | <b>-0.237</b>                        | <b>0.030</b> |

# Multiple Linear Regression between first and second follow up

|  | $\Delta$ LVM (g)<br>( $r^2=0.254$ ) |              | $\Delta$ EDV (ml)<br>( $r^2=0.560$ ) |         |
|--|-------------------------------------|--------------|--------------------------------------|---------|
| Covariate  | $\beta$                             | P Value      | $\beta$                              | P Value |
| Age (years)  | -0.210                              | 0.272        | -0.348                               | 0.133   |
| Gender   | -0.214                              | 0.166        | -0.089                               | 0.638   |
| BSA (m <sup>2</sup> )                                | 0.756                               | 0.010        | 0.519                                | 0.126   |
| HR (bpm)   | 0.017                               | 0.907        | -0.130                               | 0.416   |
| SBP (mmHg)   | 0.077                               | 0.664        | -0.007                               | 0.971   |
| LVM (g)  | -0.586                              | 0.004        | –                                    | –       |
| EDV (ml)   | –                                   | –            | -0.476                               | 0.034   |
| FU Length (month)                                    | 0.249                               | 0.096        | 0.079                                | 0.661   |
| Anti-hypertensive                                    | 0.006                               | 0.966        | 0.018                                | 0.913   |
| <b>Baseline Mean MWS<br/>(kdynes/cm<sup>2</sup>)</b> | <b>0.355</b>                        | <b>0.021</b> | 0.140                                | 0.434   |



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