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# Systematic Review and Meta-Analysis of the Effects of Age, Body Size and Exercise on Cardiovascular Parameters

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# Systematic Review and Meta-Analysis of the Effects of Age, Body Size and Exercise on Cardiovascular Parameters

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## 1. GOAL:

**To correlate Inputs with Cardiovascular Parameters**

| Inputs/ Predictors | Age, Height, Weight, Exercise intensity (MET) Body Surface Area (BSA), Body Mass Index (BMI), | | |
|---|---|---|---|
| Cardio-vascular parameters | Volumes | Ventricles | Left/Right, End-Diastolic/Systolic |
| | | Atria | Left/Right, Mean |
| | Pressures | Ventricles | Left/Right, End-Diastolic/Systolic |
| | | Atria | Left/Right, Mean |
| | | Vascular | Aortic/Pulmonary Pressures |
| | Flowrate | | Cardiac Output |
| | Resistance | | Systemic Vascular Resistance |

## 2. INTRODUCTION:

| VOLUMES | | | |
|---|---|---|---|
| | | RV | LV |
| End-Diastolic Volume | (EDV) | 144 mL(± 23 mL) | 142 mL (± 21 mL) |
| End-Systolic Volume | (ESV) | 50 mL (± 14 mL) | 47 mL (± 10 mL) |
| Stroke Volume | (SV) | 94 mL (± 15 mL) | 95 mL (± 14 mL) |
| Ejection Fraction | (EF) | 66% (± 6%) | 67% (± 4.6%) |
| Cardiac Output | (CO) | 4.0 – 8.0 L/min | 4.0 – 8.0 L/min |

| Pressures | | |
|---|---|---|
| Central Venous Pressure | | 3 – 8 mmHg |
| Right Ventricular Pressure | Systolic | 15 – 30 mmHg |
| | Diastolic | 3 – 8 mmHg |
| Pulmonary Artery Pressure | Systolic | 15 – 30 mmHg |
| | Diastolic | 4 – 12 mmHg |
| Pulmonary Capillary Wedge Pressure | | 2 – 15 mmHg |
| Left Ventricular Pressure | Systolic | 100 – 140 mmHg |
| | Diastolic | 3 – 12 mmHg |

**Table 1:** Typical values of cardiovascular parameters observed in healthy humans at rest [1].

- **The values of these cardiovascular parameters change with respect to age, height, weight and intensity of exercise [2].**
- Previous work reports only the correlation coefficients relating predictors to parameters using multiple variable analysis, providing only relationship trends.
- Previous studies use the data collected from their own experiments or other health studies and databases.
- This study uses **Meta-Analysis** to build **Multivariable Regression Models** on previously published data.

## 3. MATERIALS:

**Table 2:** Data selection and training set details

| | LVEDV | LVESV | RVEDV | RVESV |
|---|---|---|---|---|
| Final No. of Articles included | 23 | 11 | 14 | 6 |
| Total No. of Datapoints | 61 | 46 | 38 | 31 |
| Cross-Validation (# of folds) | 10 | 5 | 5 | 5 |

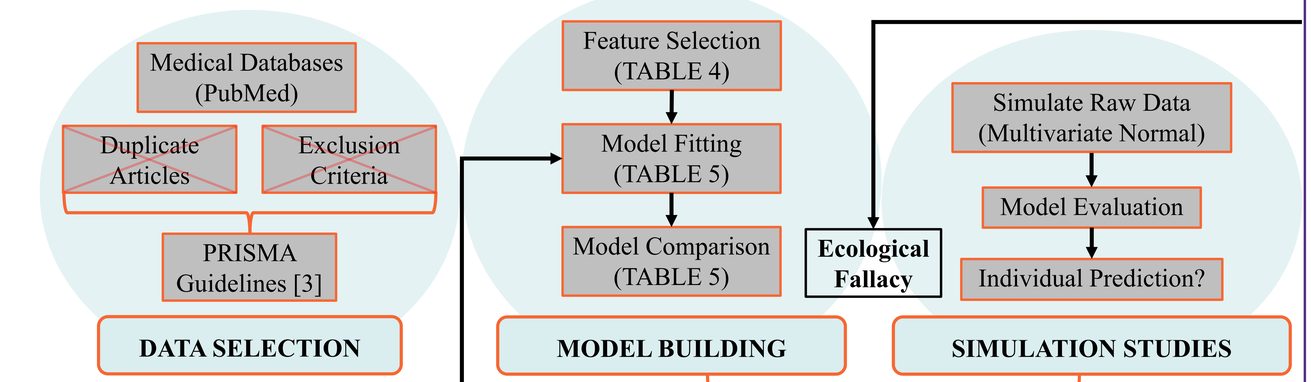
➢ **Inclusion criteria:**

✓ Subjects **without** any disorder or disease such as hypertension, coronary artery disease, diabetes, renal disease, etc. were included.

✓ Data collected via all imaging modalities was included.

## 4. METHODS:

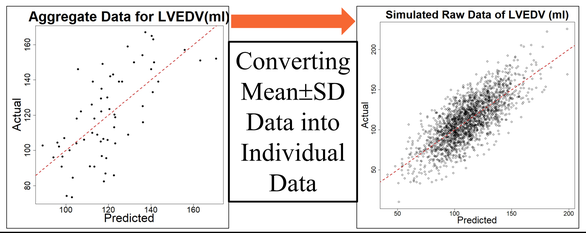
**Figure 1:** Flowchart of the modeling approach.




❖ The total number of datapoints (Table 2) for each parameter is low. Repeated cross-validation (5 or 10-fold x 3 times) is used to compensate for the small dataset.

❖ For parameters such as Pulmonary Pressure, LA/RA Pressures and Volumes, the data available for healthy subjects is not enough to build good multiple regression models.

**FINAL MODELS**
LVEDV, LVESV, RVEDV, RVESV, Aortic Pressure, CO, SVR




❖ **Model Fitting** uses aggregate data as the training set of the regression model.

❖ **Ecological Fallacy [4]:** Inferences about individuals cannot be deduced directly from the inferences about the group to which the individuals belong.

❖ **Simulation Studies** are being conducted to generate individual-level data and evaluate the regression models for individual prediction. [5]

## 5. RESULTS:

| | Output | Features Selected |
|---|---|---|
| 1 | LVEDV | Height, Weight |
| 2 | LVESV | Age, Height, Weight |
| 3 | RVEDV | Age, Height, BMI |
| 4 | RVESV | Age, Height |
| 5 | Pao | Age, BMI, MET |
| 6 | CO | Age, BMI, MET |

**Table 4:** The Penalized Regression Model (LASSO) was used to reduce the number of predictors used for building the regression model. [6]

| Root Mean Squared Error (ml) | | | | | |
|---|---|---|---|---|---|
| | Model | LVEDV | LVESV | RVEDV | RVESV |
| 1 | Linear | **21.32** | 8.11 | 22.74 | 17.03 |
| 2 | PLS | 20.02 | **7.88** | **21.01** | **16.12** |
| 3 | ENet | 21.32 | 8.32 | 22.44 | 16.45 |
| 4 | MARS | 20.96 | 7.43 | 17.94 | 15.83 |
| 5 | NNet | 18.34 | 7.25 | 17.66 | 14.77 |
| 6 | SVM | 16.64 | 6.92 | 19.13 | 15.51 |

**Table 5:** Linear, Partial Least Squares, Elastic Net, Multivariate Adaptive Regression Splines, Neural Network, Support Vector Machine Models are compared using the RMSE of the predicted vs. actual data.

The **Final Models** are selected by considering the following:

- RMSE of the model predictions vs. actual data (Table 5).
- Visual scrutiny of the plots of the model to check for realistic range of prediction and overfitting (Figure 2).
- Comparison of the training set RMSE to the cross-validated set RMSE to numerically check for overfitting.

## 6. GRAPHS:

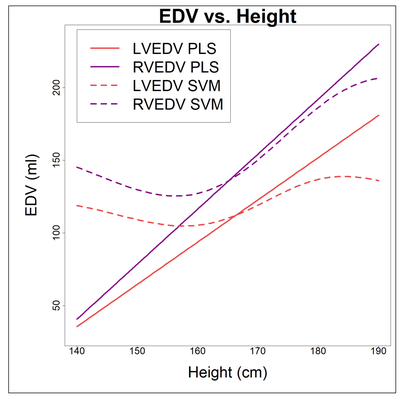



**Figure 2:** Other than Height, the other predictors (Age, Weight, BSA, BMI) are kept constant for this graph. All models show a positive trend for both the LV and RV.
A linear regression model (PLS) is compared with a highly non-linear (SVM) model. The rise and fall of the SVM graph over the range of height could be interpreted as overfitting.

## 7. APPLICATIONS AND FUTURE WORK:

➢ These specific cardiovascular parameters are considered because they are important metrics of interest used by clinicians.

➢ The models could be used for preliminary patient diagnosis if abnormal values are detected.

❖ More data for LA/RA volumes and pressures, Pulmonary vascular parameters needs to be collected to build similar predictive models.

❖ The same modeling procedure could be followed to build regression models for a cohort with some disease to understand the deviation of their cardiovascular parameters from the healthy population.

❖ Cardiovascular parameters are also affected by other variables such as diastolic filling rate, peak filling blood velocity, cardiac wall thickness, etc. Therefore, adding more variables will increase prediction fidelity.

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