Body Fat Percentage Model

STAT 628 Module 2 - Group 6
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Motivation

- **Background:** Body fat percentage can be used as a metric for overall health and fitness
- **Problem:** High-accuracy estimates of body fat percentage tend to be complex to measure or require specialized tools:
  - Skin-fold calipers
  - Measuring body density via water displacement
- **Goal:** Determine a model for estimating body fat percentage in men that is:
  - **Simple**
  - **Accurate**
  - **Robust**

Data Cleaning

- **Imputation:**
  - Height : We impute due to mismatches between data and BMI formula

Individual (IDNO)	Original Obs. (m)	Imputed Obs.(m)	Imputation Method
42	**0.74**	**1.76**	**BMI = WEIGHT(kg)/HEIGHT(m)^2**

  - Body Fat : We impute due to the laws of the human body

Individual (IDNO)	Original Obs. (%)	Imputed Obs.(%)	Imputation Method(where SEX is 0 for female and 1 for male)
182	**0**	**14.72**	**Body fat=(1.2 x BMI)+(0.23 x AGE)-(10.8 x SEX)-5.4**

- **Final Cleaned Data:** n = 252 with p = 14 predictors
  - Predictors : ADIPOSITY, HEIGHT, WEIGHT, NECK, CHEST, ABDOMEN, HIP, THIGH, KNEE, ANKLE, BICEPS, FOREARM, WRIST

Model Trade-offs

- **Simplicity:** Linear models with no more than 2 parameters
  - Simplicity scoring will favor 1-parameter models

- **Accuracy:** Correlation Coefficient (R^2)
  - Measures strength of linear relationship between body fat percentage and the parameter(s)

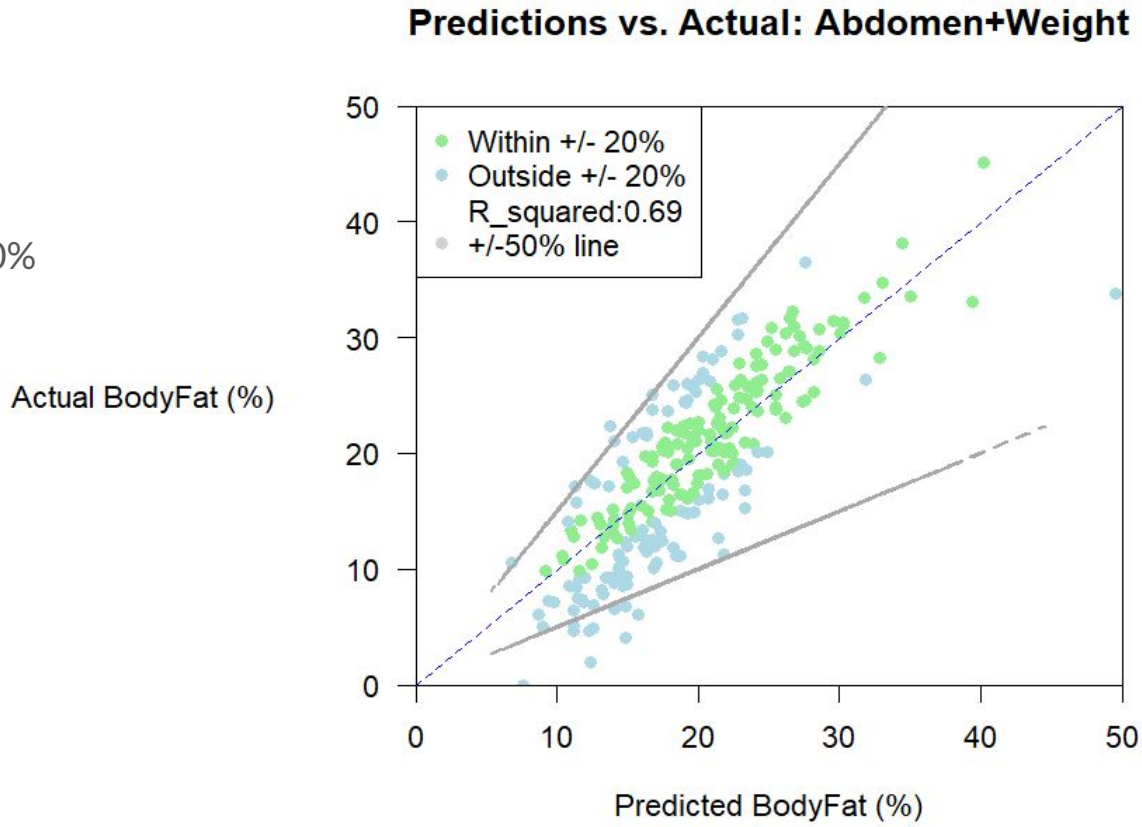
- **Robustness:** Check sum of squares for 4 points against a prior model: US Navy Method
  - US Navy method uses abdomen, height, and neck measurements
  - Calculator used: https://www.calculator.net/body-fat-calculator.html

Model Evaluation

Model	R^2	Number of Parameters	Sum of Squares with US Navy Method
ABDOMEN	**0.67**	**1**	**16.78**
ABDOMEN + WEIGHT	**0.69**	**2**	**7.98**
ABDOMEN + HEIGHT	**0.67**	**2**	**16.63**

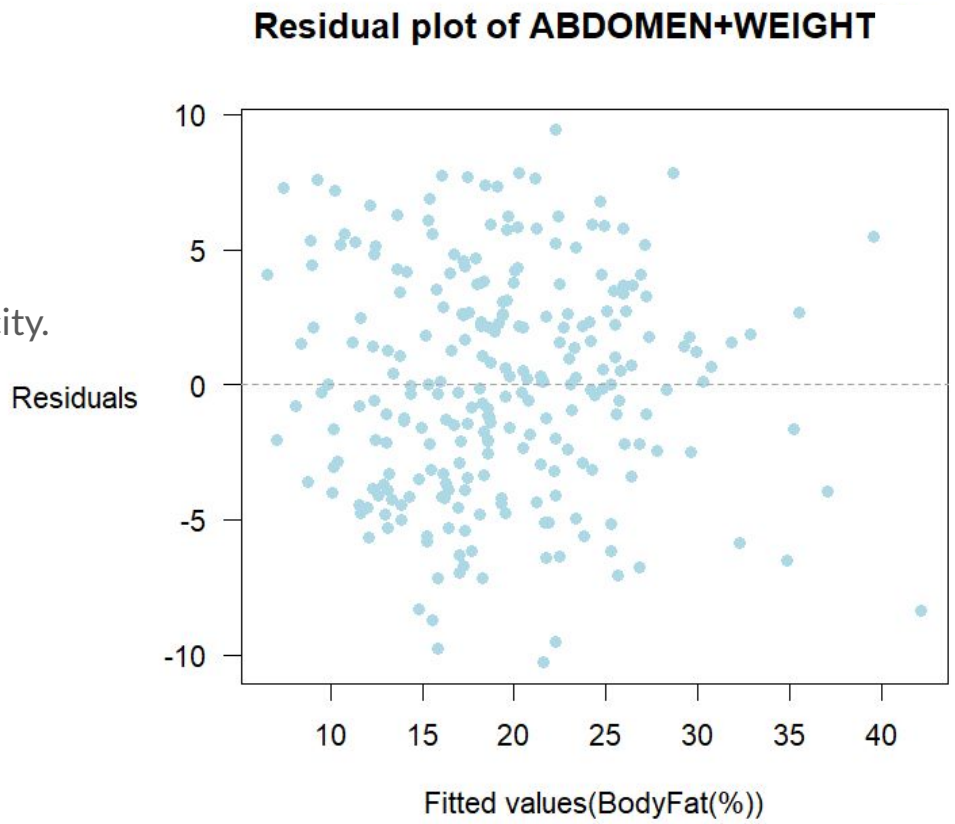
Observations

- Number of points within 20% of the true value: 147/252



Observations

- No clear pattern in residuals:
  supports linearity and homoscedasticity.



Model Strengths and Weaknesses

Final Model: Body Fat ~ -36.92+ 0.88*ABDOMEN-0.31*WEIGHT

Strengths

- Explains 69% of the variation in body fat percentage.
- Simplicity: Only 2 predictors
- Robustness: Lowest Sum of Squared Differences compared with prior model & residual plots

Weaknesses

- Prediction accuracy:
  - Only 58% of predictions fall within ±20% of the true value.
  - Only 91% of predictions fall within ±50% of the true value.

Shiny App Demo

https://amerkelz.shinyapps.io/module2_app/

References

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“Body Fat Calculator.” Calculator.Net, www.calculator.net/body-fat-calculator.html. Accessed 16 Oct. 2024.

Akinwande, M. , Dikko, H. and Samson, A., (2015). “Variance Inflation Factor: As a Condition for the Inclusion of Suppressor Variable(s) in Regression Analysis.” Open Journal of Statistics, 5, pp. 754-767. Web.

Thank you!

Appendix

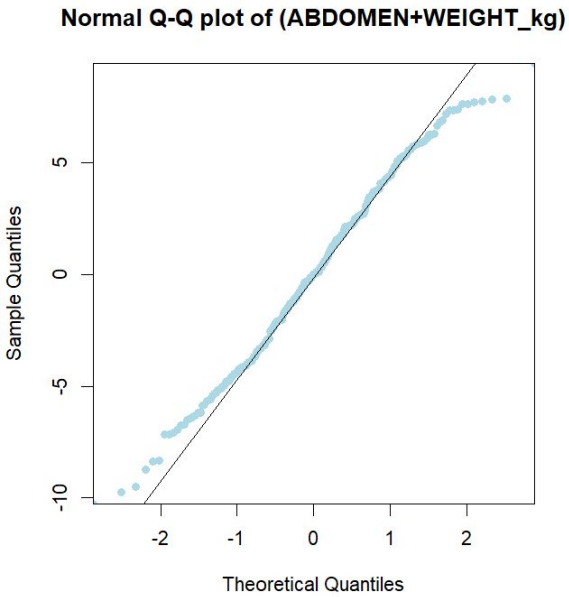
Model	ABDOMEN+WEIGHT	ABDOMEN+HEIGHT
VIF value	4.73	1.04

Table 1: VIF values for the 2 factor models

$$\mathrm{VIF}_i = \frac{1}{1 - R_i^2}$$

where $R^2{}_i$ is the coefficient of determination of the regression equation in step one, with X_i on the left hand side, and all other predictor variables (all the other X variables) on the right hand side.

Appendix


Normal Q-Q plot of (ABDOMEN+WEIGHT_kg)
Sample Quantiles
5
0
-5
-10
-2
-1
0
1
2
Theoretical Quantiles