Exploring Anthropometric Measurements for Prediction of Body Build Weight and Gender

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Outline

Background

- Anthropometric measurements evaluate the size, shape, and composition of the human body
    - Constant measures: skeletal measurements and three “bony” girths
    - Changeable girths: shoulder, chest, waist, navel, hip, thigh, bicep, forearm, calf

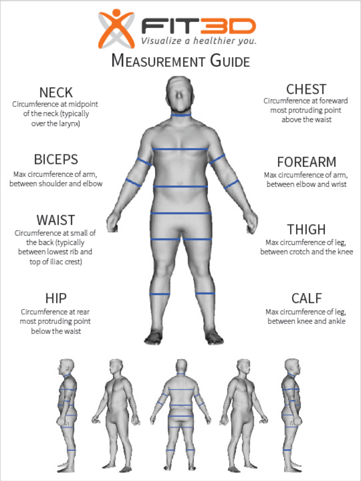

Figure: Fit3D Male Measurement Guide

http://healthandfitnesstesting.nz/resources/fit3d-male-measurement-guide/

Objective

Our objective was to evaluate the relationships between body measurements, and to develop and evaluate prediction models for body build weight and gender.

- Aim 1a: Predicting weight from body build measures
- Aim 1b: Utility of BMI in relation to body build weight
- Aim 2: Predicting gender from skeletal measures

Methods

- Description of data set:
  - 247 males and 260 females
  - Twenties to early thirties
  - Physically active
  - Nine skeletal and twelve girth measurements
  - Additional variables: height, weight, age, gender
- Transformation of variables:
  - Log transformation of weight

Aim 1a: Predicting weight from body build measures

Linear model

- Model 1.1
  - All skeletal measurements + height + gender + age
  - Model selection: AIC
- Model 1.2
  - Six skeletal measurements + three constant girth measurements + height + gender +age
  - Model selection: AIC

Aim 1a: Predicting weight from body build measures

Quadratic model

- Method 1: sum, square, and multiplied by height
  - Model 2.1
    - Quadratic term of all girth measures + age + gender
  - Model 2.2
    - Quadratic term of all girth measures + age
  - Model 2.3
    - Quadratic term of three constant girth measures + gender + age
- Method 2: multiplied by height, sum,and square
  - Model 2.4
    - Quadratic term of all girth measures + age + gender
  - Model 2.5
    - Quadratic term of three constant girth measures + gender + age

Aim 1b: Utility of BMI in relation to body build weight

- Body build weight
  - Predicted weight from our linear model
  - Normal weight given the body build frame
- Regressed the body build weight (log transformed) on BMI with/without gender to evaluate the utility of BMI in relation to body build weight
- High or low fat mass
  - Difference between measured waist girth and body build waist girth predicted by chest, biiliac, and bitrochanteric diameters as well as chest depth
  - A difference of $>$ 5 cm or $<$ -5 cm was defined as high or low fat mass
- High or low muscle mass
  - Difference between measure forearm girth the body build one predicted by wrist girth, chest diameter and chest depth
  - A difference of $>$ 1 cm or $<$ -1 cm was defined as high or low muscle mass

Aim 2: Predicting gender from skeletal measures

- Logistic regression using forward and backward stepwise selection methods
  - P-value for addition: 0.1
  - P-value for removal: 0.25
- Model selection completed with and without height
- Akaike information criterion
- Sensitivity and specificity
- Internal validation: ten-fold cross validation

Results

Table 1. Baseline characteristics (Median (25th, 75th percentile) or N(%))

	Overall (N=507)	**Female (N=260)**	**Male (N=247)**
Age (years)	27 (23, 36)	26 (22, 34)	29 (24, 37)
Height (cm)	170.3 (163.8, 177.8)	164.5 (160, 169.5)	177.8 (172.8, 182.9)
Weight (kg)	68.2 (58.4, 78.9)	59 (54.4, 65.7)	77.3 (70.9, 85.5)
BMI Category			
Less than 18.5 kg/m^2	13 (2.6)	12 (4.6)	1 (0.4)
18.5-25 kg/m^2	344 (67.9)	203 (78.1)	141 (57.1)
25-30 kg/m^2	132 (26.0)	36 (13.9)	96 (38.9)
Over 30 kg/m^2	18 (3.5)	9 (3.4)	9 (3.6)

Aim 1a: Predicting weight from body build measures

- Best linear model: Model 1.2
  - log(weight) = skeletal biacromial + skeletal biiliac + skeletal bitrochanteric + skeletal chest depth + skeletal chest + skeletal elbow + knee girth + ankle girth + wrist girth + age + height + gender + intercept
  - Ten-fold cross validation yielded a pseudo R^2 of 0.9140.
- Best quadratic model: Model 2.2
  - Transformation method 1: sum, square, and multiplied by height
  - All girth measures in quadratic form + age
  - Ten-fold cross validation yielded a pseudo R^2 of 0.9594.
- Linear model was chosen due to simpler form and better interpretability.

Aim 1b: Utility of BMI in relation to body build weight

- Regressing body build weight on BMI
  - adjusted R^2=0.540
  - pseudo-$R^2 = 0.536$ by ten-fold cross-validation
- Regressing body build weight on BMI and gender
  - adjusted R^2=0.748
  - pseudo-$R^2 = 0.750$ by ten-fold cross-validation
- Models assessing fat mass and muscle mass
  - Fat mass: adjusted $R^2 = 0.776$
  - Muscle mass: adjusted $R^2 = 0.787$

Aim 1b: Utility of BMI in relation to body build weight

Table 3. BMI for subjects with high/low fat mass or muscle mass.

(a)

	High fat mass, n (%)			Low fat mass, n (%)		
BMI	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
<20 kg/m^2	2 (2.5)	0 (0)	2 (5.6)	13 (16.3)	3 (6.5)	10 (29.4)
20-25 kg/m^2	26 (32.9)	13 (30.2)	13 (36.1)	56 (70.0)	33 (71.7)	23 (67.7)
25-30 kg/m^2	39 (49.4)	24 (55.8)	15 (41.7)	11 (13.8)	10 (21.7)	1 (2.9)
>30 kg/m^2	12 (15.2)	6 (14.0)	6 (16.7)	0 (0)	0 (0)	0 (0)

(b)

	High muscle mass, n (%)			Low muscle mass, n (%)		
BMI	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**
<20 kg/m^2	3 (2.8)	1 (1.3)	2 (7.4)	22 (19.5)	3 (6.5)	19 (28.4)
20-25 kg/m^2	56 (52.8)	40 (50.6)	16 (59.3)	70 (62.0)	26 (56.5)	44 (65.7)
25-30 kg/m^2	43 (40.6)	35 (44.3)	8 (29.6)	18 (15.9)	16 (34.8)	2 (3.0)
>30 kg/m^2	4 (3.8)	3 (3.8)	1 (3.7)	3 (2.7)	1 (2.2)	2 (3.0)

Aim 2: Predicting gender from skeletal measures

Logit(gender)= chest depth + bitrochanteric + biacromial + wrist + knee + elbow + height + intercept

- Forward stepwise regression
- AIC: 127.0
- Sensitivity: 96.5%
- Specificity: 95%
- Internal validation R^2: 0.8420

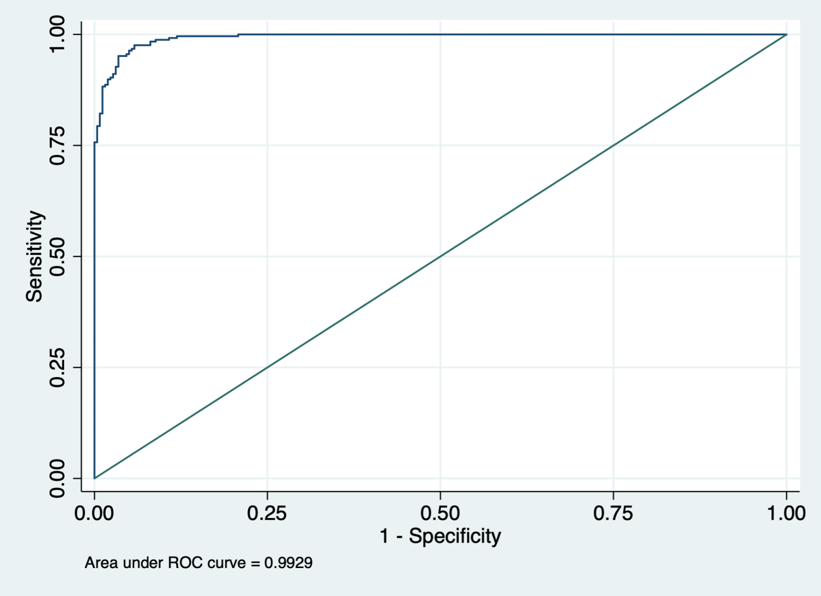

Figure: ROC curve of the prediction model

Discussion

- Aim 1a
  - Both linear and quadratic models show good predictability.
  - Linear model was chosen due to simpler form
  - The best model contains skeletal biacromial, skeletal biiliac, skeletal bitrochanteric, skeletal chest depth, skeletal chest, skeletal elbow, knee girth, ankle girth, wrist girth, age, height, and gender.
- Aim 1b
  - BMI is a poor predictor for the body build weight.
  - Subjects with high fat or muscle mass
    - A larger body frame for their height
    - BMI tends to classify them as overweight or obese
    - Does not tell whether extra weight is due to fat or muscle
  - Similar for subject with low fat or muscle mass

Discussion

- Aim 2
  - Height, chest depth, bitrochanteric, biacromial, wrist, knee, and elbow skeletal measurements best predicted gender.
  - Addition of height adds predictive ability.
- Limitations
  - Different model selection methods in each aim
  - Lack of external validation

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Questions?