**Methods**

*Aim 1a.*

The outcome weight was log transformed for normality. First, linear regression was used for model selection where the input variables include all skeletal measurements, height, gender and age. The selection criterion is AIC. Skeletal ankle, knee, and wrist were replaced with corresponding girth measures to compare the model performance with the first model. Additional analysis was done to explore the efficiency of quadratic models using all girth measures, as well as using three constant girth measures – ankle, knee, and wrist.

Model diagnosis was conducted on the two best models, one linear model and the other quadratic model. 10-fold cross validation was done to assess the internal validity.

**Results**

*Aim 1a.*

First, the linear regression model selection was done using all skeletal measurements, height, gender, and age. Backward and forward selection yielded the same result. The best model, named Model 1a-1-1, contained variables of skeletal chest depth, skeletal chest, skeletal knee, skeletal bitrochanteric, skeletal wrist, skeletal biiliac, skeletal biacromial, height, and age. Then we replaced skeletal ankle, knee, and wrist with corresponding girth measures, and re-ran the same selection procedure. The best model, named Model 1a-1-2, contained variables of skeletal biacromial, skeletal biiliac, skeletal bitrochanteric, skeletal chest depth, skeletal chest, skeletal elbow, knee girth, ankle girth, wrist girth, age, height, and gender. Between the above two models, the second model is preferred due to smaller AIC (-1481.04), which is our best linear model. Ten-fold cross validation was used for internal validation, which yields a pseudo R^2 of 0.9140.

Second, quadratic models were fitted on all girth measures plus gender and age, as well as only three constant girth measures (knee, ankle, and wrist) plus gender and age. There are two ways to model the quadratic relationship between girth measures and weight. One (method 1) is to sum all girth measures, square the sum, and then multiply the sum by height. The other (method 2) is to multiply each measure by the height, take the sum, and then square the sum. The quadratic term was then fitted in a linear model with gender and age as covariates. The first quadratic model, named Model 1a-2-1, had all girth measures, age, and gender using method 1. However, the gender is not significant, and the corresponding confidence interval was quite close to null, so we decided to run another model using the same method but without gender. That model is called Model 1a-2-2. The third quadratic model, named Model 1a-2-3, had all girth measures, age and gender using method 2. The fourth model, named Model 1a-2-4, had only three constant girth measures, age and gender using method 1. The fifth model, named Model 1a-2-5, had only three constant girth measures, age and gender using method 2. AIC was used to assess the model performance, and the best quadratic model is Model 1a-2-2 (AIC=-1853.18). Ten-fold cross validation was used for internal validation, which yields a pseudo R^2 of 0.9594.

The summary of all models in Aim 1a is displayed in Table 2, and regression diagnostics plots are shown in supplements.

**Discussion**