CHAPTER 4.

FINAL REGRESSION– APPLICATION GUIDE

4.1 Introduction

In this chapter we will try to use all available information for predicting REE. We will examine males and females together by using a dummy variable that indicates if an athlete is a man or a woman. Sex is equal to zero when the athlete is a man and equal to one when the athlete is a woman. Sex will be used to create interactions with the other explanatory variables (weight, height, age, nofat.wt, and fat.wt) in order to investigate if there is differential influence to energy expenditure between sexes for every explanatory variable.

Although men and women have different body types (see section 1.5), they may behave as the same energy mechanism. If that happens then a sex-dummy variable is not significant in a regression model.

4.2 Derivation of new variables

New interaction variables will be derived and tested in order to create new more effective equations. These variables are useful for indicating differences on the effectiveness of the explanatory variables between sexes.

The new derived variables are:

$$\text{SEX.WGT} = \text{SEX} \cdot \text{WEIGHT} = \begin{cases} \text{WEIGHT} & \text{for females} \\ 0 & \text{for males} \end{cases}$$

$$\text{SEX.HGT} = \text{SEX} \cdot \text{HEIGHT} = \begin{cases} \text{HEIGHT} & \text{for females} \\ 0 & \text{for males} \end{cases}$$

$$\text{SEX.AGE} = \text{SEX} \cdot \text{AGE} = \begin{cases} \text{AGE} & \text{for females} \\ 0 & \text{for males} \end{cases}$$

$$\text{SEX.FAT} = \text{SEX} \cdot \text{FAT} = \begin{cases} \text{FAT} & \text{for females} \\ 0 & \text{for males} \end{cases}$$

$$\text{SEX.NFWT} = \text{SEX} \cdot \text{NOFAT.WT} = \begin{cases} \text{NOFAT.WT} & \text{for females} \\ 0 & \text{for males} \end{cases}$$

$$\text{SEX.FTWT} = \text{SEX} \cdot \text{FAT.WT} = \begin{cases} \text{FAT.WT} & \text{for females} \\ 0 & \text{for males} \end{cases}$$

So if we use weight and sex as the only explanatory variables the Regression equation will have the following format:

$$REE = A_0 + A_1 \cdot SEX + A_2 \cdot WEIGHT + A_3 \cdot SEX \cdot WEIGHT$$

In other words two different equations will be derived:

Males: $REE = A_0 + A_2 \cdot WEIGHT$

Females: $REE = (A_0 + A_1) + (A_2 + A_3) \cdot WEIGHT$

In fact we assume that both the constant and the slope vary between sexes.

4.3 Derived equation with interactive variables

Using the backward elimination method with all mentioned variables, except from height (since it is highly correlated with weight), we derive a new regression model with the following explanatory variables:

NOFAT.WT, SEX.NFWT, FAT.WT, AGE

The only outlier is observation '208' which is a 16 years old boy with extremely high levels of REE maybe due to stress at the time of the measurement. The following equations have been derived after removing this outlier.

$$REE = 646 + 17.6 \cdot NOFAT.WT - 3.6 \cdot SEX.NFWT + 7.9 \cdot FAT.WT - 8.4 \cdot AGE$$

with $R^2_{adj} = 0,724$ and Standard Error of Estimation = 186,44

This equation can be presented as two different equations depending on sex.

Males: $REE = 646 + 17.6 \cdot NOFAT.WT + 7.9 \cdot FAT.WT - 8.4 \cdot AGE$

$$\text{Females: } REE = 646 + 14 \cdot NOFAT.WT + 7.9 \cdot FAT.WT - 8.4 \cdot AGE$$

These derived equations satisfy all assumptions of the linear regression model and can be applied to Greek athletes when the body fat proportion is known. The average difference of the predicted amount of calories from the real amount of REE is about 146 calories that do not significantly influence the variation of the body weight.

If the body fat proportion is unknown the equations that we recommend are the following:

$$REE = 721 + 14{,}9 \cdot WEIGHT - 3{,}8 \cdot SEX.WGT - 6{,}8 \cdot AGE$$

with $R^2_{adj} = 0{,}716$ and Standard Error of Estimation = 189,18

This equation can be presented as two different equations depending on sex.

$$\text{Males: } REE = 721 + 14.9\ WEIGHT - 6.8\ AGE$$

$$\text{Females: } REE = 721 + 11.1\ WEIGHT - 6.8\ AGE$$

The average difference of the predicted amount of calories from the real amount of REE is about 149 calories that do not significantly influence the variation of the body weight. These derived equations also satisfy all the assumptions of the linear regression model.

4.4 Conclusions

Considering all the above equations and by examining the regression coefficients we may conclude how each variable influence REE. Positive/negative coefficients show a positive/negative correlation between the variables and REE. Differences on respective coefficients between sexes indicate differential influence on REE.

- Females have lower metabolism, which means that a female needs fewer calories for maintenance than a male, with the same body composition characteristics (Pavlou, 1992).
- Metabolism slows down, as the person gets older (Ravussin and Bogardus, 1989).
- The larger in size the individual the more the energy is needed (weight) for maintenance (Pavlou, 1992).
- Fat body mass needs less energy for maintenance than fat free body mass does. In fact fat is inactive and is used as an energy store. Nutrition

assumes that fat does not need any energy for maintenance and is burned only when energy expenditure becomes higher than energy incoming from feeding (Pavlou, 1992).

- Fat free body mass for Males has more energy needs for maintenance than Females, a fact that indicates a difference in the muscle composition between the two sexes (Pavlou, 1992).

The presented equations, not only assist to easily calculate REE for athletes but also drive to important nutrition conclusions that aid in increasing the understanding of the human body and mechanism. These equations can be easily applied by using following simple steps as explained in the paragraph below.

4.5 Application guide

In this section the procedure for planning a weight loss/gain is detailed using the presented predictive equations. The example is a Greek elite athlete of the Greek National Boxing team with the following characteristics:

Sex = Male

Age = 30

Height = 180 cm

Weight = 81 kg

Fat Proportion = 17%

The only daily activity is training twice a day. The level of activity except from training is ‘Chair – bound or bed – bound (PAL = 1.2 see Table 1.6.1).

In the morning he does the following program:	Weight·Time·TAL
30 minutes Jogging, TAL = 0,139	337,7
60 minutes Weight Training, TAL = 0,080	388,8
15 minutes stretching, TAL = 0,024	29,2
In the afternoon he does the following program:	
15 minutes warm up, TAL = 0,090	109,3
60 minutes Boxing Training, TAL = 0,138	670,7
10 minutes Boxing Competition, TAL = 0,222	179,8 +
(For TAL values see Table 1.7.1)	1.715,5

Total Activity Calories = 1.715,5

Using the first equations (that use the fat info) of the previous chapter we found REE to be 1.626 calories. Using the equations that do not use fat info, we found REE to be 1.726 calories. We take Daily Energy Expenditure using the formula DEE = REE·PAL = REE·1.2 = 2.023 and 2.071, respectively.

In order to find the Total Energy Expenditure for the above-mentioned athlete, we just use the formula: TEE = DEE + AEE (Activity Energy Expenditure) = (2.023 or 2.071) + 1715.5 = 3.738 and 3.786 calories respectively.

Suppose now that this athlete wants to participate in the lower category of 75 Kg, so he wants to lose 6 kilos by decreasing only his body fat weight.

Table 4.5.1 Example of Present Target Status

	Present Status	Target Status
Total Weight	81 Kg	75 Kg
Fat Free body weight	67,23 Kg	67,23 Kg
Fat body weight	13.77 Kg	7,77 Kg
Fat Proportion	17 %	10 %

In order to help this athlete manage his target weight in the right way, the aforementioned steps need to be followed.

1. Estimate TEE = 3750 as previously calculated. Use the 95% confidence interval of the estimated REE for accuracy.
2. Create Table 4.5.1
3. Start measuring the daily calorie consumption for a week, without changing his habits and weight.
4. Compare this amount of calories with the estimated 95% confidence interval of TEE.
5. Decide the Final TEE (let's assume 3700) and decrease by 400 this amount. So the new amount of calories is 3700 – 400 = 3300. The daily energy consuming must not be over 3300 for the next 15 days.
6. After 15 days check whether the athlete has decreased his weight. Normally, he should have lost about 1 kilo.

After 1 month he should have lost about 2 kilos and TEE should be again estimated. In 3 months the athlete should manage the target status and be able to participate in the category of 75 Kg.

If the model fails to provide the expected results in a month period we should measure REE by using special equipment.

4.6 Summary

Elite athletes always try to manage the optimum body weight. Measuring the exact TEE, by using special equipment, is rarely feasible for all athletes. Not only because of the unavailability of the equipment but also because several conditions must be satisfied in order to manage an accurate measurement. For example measurement of REE, before important competitions, most of the times show unreliable levels of REE.

Fortunately accurate measurements of REE are available in the Hellenic Sports Research Institute (OAKA). This fact makes it possible to derive and use our predictive equations, which are suitable Greek athletes, instead of using old and not statistically proven equations. It is the first time that this subject has been analyzed from a statistical point of view.

Our equations are proposed for predicting REE of healthy athletic individuals living in Greece. For best results, this equation should be applied to persons that are aged between 11 and 40 years old since cases that do not belong in this age interval have not been used in our analysis. These equations can also be applied to different kind of individuals but with no good result guaranty.