CHAPTER 2.

SAMPLE OF GREEK ATHLETES

2.1 Introduction

Energy needs are supplied by the various foods and food supplements that athletes consume. The contribution of the energy sources to the total energy pool is mainly determined by the nature, intensity and duration of the activity, as well as by the energy source availability. Additional factors are the gender of the athlete, his/her body weight, previous experience and training status, time of day, weather conditions and altitude. Overall, a qualitative and quantitative energy balance must be maintained on a day-to-day basis for athletes to compete optimally. A positive energy balance results in the accumulation of excessive body fat, while a negative energy balance leads to weight loss. In both cases optimal athletic performance is hindered.
The question is: how many calories an athlete needs, during competition and the various phases of training, for maintenance of an optimal body weight and at the same time assist him/her to compete optimally.

It is very difficult (if not impossible) to assess the energy needs of the elite athlete. The importance of achieving 'optimal competitive body weight' and how energy consumes influences it, cannot be emphasized enough. We should bear in mind that the difference of only 50g of extra body weight might account for the variation in placement between 1st and 6th place in competition, or not allow the athlete to compete in other cases at all (boxing, wrestling, weight lifting).

The various equations available for calculating daily energy need for athletes are not accurate enough, since no athletes were included in the populations from which they derived. The ability to accurately predict daily energy needs for the elite athlete is very important since training and proper nutrition represent the two most important determinants for successful competition.

The aim of this thesis is to check whether the most commonly used predictive equations are applicable to Greek elite athletes and, if not, to develop a new equation that will be accurate enough.

2.2 Predictive equations to estimate REE of adults

REE can be accurately measured by direct or indirect calorimeter, but it is simpler and cheaper, in practice, to use predictive regression equations. Since 1951, a plethora of equations to predict REE exist, some are easier to use than others. Some predictive equations (Aub and Du Bois, 1917) tend to over-estimate REE, as the subjects measured by these authors were under thermal stress and anxious. In contrast, other equations (Robertson and Reid, 1952) underestimate REE, as they were based on the lowest recorded values of metabolic rate. Finally, while Quenouille's analysis (Quenouille et al, 1951) was comprehensive, the equations were too complicated to be of routine practical use. Recently, predictive equations (Schofield, 1985) were published that became the basis for estimating energy requirements in man.

The Schofield analysis and equations, based on a database of 114 published studies of REE, representing 7173 data points, is the largest and most comprehensive analysis of REE to date. While the Schofield equations predict REE accurately in many individuals from temperate climates, they seem to be less accurate in predicting REE in populations in the tropics (Henry and Rees, 1991), (Piers and Shetty, 1993) and North America (Clark and Hoffer, 1991) and appear to over-estimate REE in many populations (Piers and Shetty, 1993), (Soares et al, 1993), (Hayter and Henry, 1993).

There are several reasons to suggest that there is a need to re-analyse the worldwide data on REE using stringent inclusion criteria in order to generate more valid equations to predict REE in humans worldwide.

Schofield collected data for his study a decade ago. Since then several laboratories have produced a large number of good quality REE data for different age, sex and ethnic groups that also need to be included.

Henry and Rees have identified over 1500 data points for Caucasian subjects in the old literature that meet all the strict criteria used by Schofield, but were not included; these values also need to be incorporated.

Certain age groups (children and adults over 60) are under-represented, and these parts of the database need to be expanded in order to generate more reliable predictive equations for those age ranges.

Close examination of the Schofield databases shows that of the approximately 6000 REE values for males between 10-60 years, over 3000 (50%) come from Italian military subjects (soldiers). The validity of including such a disproportionate number of Italian military subjects may need to be queried, firstly, because the Italian group appears to have a higher REE per kg than any other Caucasian group (Hayter and Henry, 1993), and secondly, because they may not be representative of the general Italian population. In fact, Schofield (1985) noted that when Italians were isolated from the rest of the sample and compared with the derived REE predictive equation there was a significant lack of fit. The inclusion of this disproportionately large Italian group with a higher REE per kg may have artificially elevated the predictive equations generated by Schofield.

If an analysis of the REE for people from the tropics and sub-tropics (Henry and Rees, 1991) points to a lower REE than predicted by the Schofield equations, this may be due mainly to the bias imposed by the dominance of the Italian data. More recent data, in fact, support the view that REE of people in the tropics are not different from those in temperate regions (North America and Europe), provided the subjects are well nourished (Henry et al, 1989) (Hayter, 1992), (Soares et al, 1993), (Piers and Shetty, 1993).

There is thus mounting evidence to suggest that the Schofield equations may overestimate REE in many populations.

2.3 Predictive equations to estimate REE of athletes

Unfortunately, international bibliography has not helped much the determination of daily calorie demand of athletes. Several published studies mention that the athletes of different sports need greater amounts of calories. However, what has not been taken into consideration is the fact that, the calories provided in several publications do not mention the real calorie needs of the athletes, but the calories that were possibly consumed in the particular period of time, when the registration took place.

The confusion that exists in the bibliography is such, that for example (Papanikolaou, 1983) provides two different ways in calculating calories. As a result, the daily calorie demands that are calculated for the same athlete differ by 500 calories per day. The equations done by Harris and Benedict do not represent the athletes, while at the same time, the equation prepared by Durnin and Passmore (1967) provide bigger amounts for the non-athletes. For example, Durnin and Passmore estimate that the daily calorie consumption of an athlete without training, who weights 60 kilos, rises up to 2446 kcal per day, (580+31,1Weight) while at the same time, for an athlete who weights 80 kilos, the daily calorie consumption rises to 3743 (815+36,6Weight) kcal per day, without taking into consideration the consumption during training.

Strauzenberg (1979) mentioned that the daily calorie demands for the athletes of velocity, leap (jump, spring) and gymnastics, rise up to 5200 Kcal, while athletes of sports, such as weight lifting, throwing etc. rise up to 6800 Kcal.

For the same categories, Short and Grandjean mentioned 3940-3034 calories respectively (Short, 1983), (Grandjean, 1989). All these efforts and some others that are not mentioned, lack the correct methodology for gathering information. Some of the conditions that are not satisfied, for analyzing our data, are the following:

- REE measurements are not made under appropriate physical conditions (see section 1.3)
- Samples are not representative for creating predictive equations for Greek athletes (see section 2.2)
- The Statistical methodologies, used, are questionable.

Realistically, the calorie needs of athletes differ from day to day and may possibly fluctuate from 1200 to 1500 Kcal, (Parizkova and Novak, 1991), (Rondogiannis et al, 1989).

Another crucial point, which should be mentioned, is the fact that the equations of calculating calorie needs do not come out of athletes and they are not representative, resulting to wrong estimates.

An athlete is a totally different "being". There is such a big difference among sports, that the calculation of the athlete's calorie needs is almost impossible, considering the existing common equations.

2.4 Established equations for predicting REE

There are several equations in international bibliographies that predict REE, most of them have limited practical use. The most famous equations are those of Harris and Benedict. These equations are used by the most of the dietitian and can be found in the majority of the nutrition sites in the Internet as for example the URLs:

http://www.hotcontracts.com/running/bmr.html

http://www.frausa.com/harben.html http://w3.one.net/~jwclymer/calorie.html

http://calc.med.edu/HarrisBenedict.htm

Some of the most important equations that have been created over the last 100 years are the following.

Harris-Benedict (1919) Equations (calories/day):

Male: REE = 66.5 + 13.8 Weight + 5.0 Height - 6.8 Age

Female: REE = 665.1 + 9.6 Weight + 1.8 Height - 4.7 Age

Weight in kilograms, height in centimetres and age in years

(WHO) FAO (1985) equations (calories/day):

Male: REE = 679 + 15.3 Weight (Age: 18 – 30)

Female: REE = 496 + 14.7 Weight (Age: 18 – 30)

Weight in kilograms

Schofield et al (1985) equations (calories/day):

Male: REE = 688.5 + 15.1 Weight (Age: 18 – 30)

Female: REE = 603.2 + 13.1 Weight (Age: 18 – 30)

Weight in kilograms

Ravussin and Bogardus (1989) equation (calories/day):

Both Male and Female: REE = 441 + 21.9 Fat Free Weight – 2.4 Age

Weight in kilograms and age in years

Henry and Rees (1991) equations (calories/day):

Male: REE = 672 + 13.4 Weight (Age: 18 – 30)

Female: REE = 614.8 + 11.5 Weight (Age: 18 – 30)
Weight in kilograms

Piers and Shetty / Soares et al (1993) equations (calories/day):
Male: REE = 849.6 + 10.6 Weight (Age: 18 – 30)
Female: REE = 595.1 + 10.9 Weight (Age: 18 – 30)
Weight in kilograms

As we can see most of the equations use only weight as explanatory variable and can be applied for a specific age interval (18 – 30). Harris and Benedict equations use age, weight and height. The Ravussin and Bogardus equation use Fat Free Body mass and age as explanatory variables and represent both males and females.

2.5 Sample description and statistics

In order to examine the calorie needs for athletes we used a sample kindly provided by Dr Pavlou, director of the Hellenic Sports Research Institute (OAKA), Dept. of Exercise Physiology/Nutrition. The sample includes 485 elite athletes (271 males and 214 females) from 12 different sports (see table 2.5.1).

REE have been measured for a significant number of Greek elite athletes from 12 different national teams. The sample can be considered as statistically representative as it contains a wide number of different kinds of activities.

Table 2.5.1 Different sports - cases

Type of sport	Males	Females
Wrestling, weight lifting, hammer throwing, boxing, martial arts	55	18
Eurhythmics, organic gymnastics	0	46
Aerobics, 3km, 5km, 10km, marathon, walk	40	23
Volley ball	13	0
Swimming	35	35
An aerobics, 100m, 200m, 400m, long jump, high jump	45	61

Football, handball	11	0
Basket ball	31	19
Rowing	19	8
Diving	6	4
Cycling	13	0
Water polo	3	0

The information that can be taken is about basic characteristics for each athlete such as: Age in years, Height in cm, Weight in kg, Sex (0 for male, 1 for female), Type of sport, the percentage of body Fat, measured REE.

Now that our sample has been described let see some important descriptive statistics from the table 2.5.2 below:

Table 2.5.2 Descriptive Statistics

Factors	Males n = 271		Females n = 214	
	Mean	Std Dev.	Mean	Std Dev.
Age	21,66	4,76	18,52	4,10
Height	180,21	10,82	166,37	9,23
Weight	77,07	14,80	58,12	12,39
Fat %	12,10%	5,72	17,45%	3,82

Statistical analysis, inside different groups of activities, using independent samples T test showed that:

- Age, height and weight means, of males, are significantly greater than the respectively of females for most of the activities, as was expected.
- Mean fat proportion of males is significantly smaller than that of females.
- No difference of weight, between sexes, is indicated for sports as: Wrestling, weight lifting, hammer throwing, boxing, and martial arts.

The previous mentioned conclusions can be explained by the existing difference of body composition between sexes (see table 1.4.1) and by the type of activity/sport.

2.6 REE explanatory variables

REE is the variable that we want to predict, using the available information of our sample. We could use only the already existed variables but it would be much better to try some new derived variables as: fat weight and fat free body mass. The variables fat.wt and nofat.wt can be computed by weight and fat as follow:

$$FAT.WT = WEIGHT \cdot (FAT/100)$$

$$NOFAT.WT = WEIGHT - FAT.WT$$

It is of great importance to see which are the variables that mostly affect REE. Table 2.6.1 presents the correlation matrix for all the variables

Table 2.6.1 Correlations Matrix

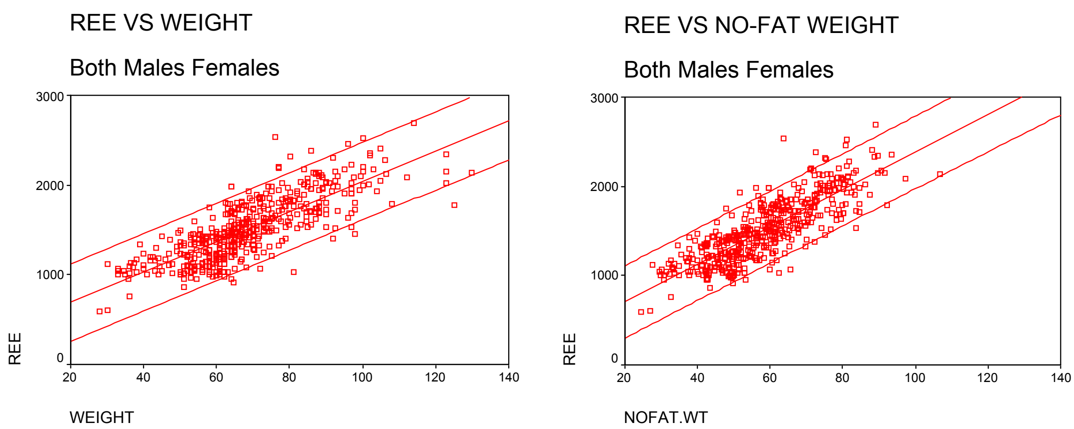
	Age	Height	Weight	Fat-Free weight	Fat weight	% Fat	REE
Age	1,00						
Height	0,30	1,00					
Weight	0,43	0,78	1,00				
Fat-Free weight	0,47	0,83	0,95	1,00			
Fat weight	0,10	0,25	0,60	0,31	1,00		
% Fat	-0,13	-0,11	0,15	-0,16	0,85	1,00	
REE	0,28	0,71	0,79	0,82	0,29	-0,11	1,00

Examining the Correlations matrix, we can come up with the following conclusions:

- The most powerful explanatory variables for REE are: Weight and Fat-Free weight since they have the strongest correlations with REE.

- All variables are significantly correlated with REE at the 0,01 level, except from Fat proportion.
- Height and weight are strongly correlated and they should not be used together as explanatory variables due to Multicollinearity (see Chapter 3) in general there are large correlations among the variables.
- The relationship between Fat-Free weight, weight and REE is impressive as the following scatter plots show.

Figure 2.6.2 Scatter plots of REE VS Weight and Fat-Free Weight



2.7 REE Prediction

As previously mentioned, in chapter 1, REE is a measure of great importance for all people and especially for athletes. It can be accurately measured by using special and expensive equipment but unfortunately this type of solution is rarely available. In practice, most of the times, simple equations are used in order to estimate REE. These predictive equations are much easier and cheaper but not always accurate and representative.

REE is a continue variable, highly correlated with easily measured variables as mentioned in 2.4. Regression analysis is used to investigate and model the relationship between response variable and one or more predictors. Least squares regression methods estimate parameters in the model so that the fit of the model is optimized.

We will use the sample of the 485 elite athletes and all the available information in order to create predictive equations for REE. The aim is to derive more accurate and more representative equations, for elite athletes that live in Greece, than those that already existed.