Body Mass Index

Body mass index is a measure of one's body fat. It is calculated by taking one's weight(kg) and dividing by the square of one's height(m).

The table(***Figure 1.0***) below gives the median BMI for females from the range of 2 years old to 20 years old in the US, in the year 2000.

Age (years)	**BMI**
2	16.40
3	15.70
4	15.30
5	15.20
6	15.21
7	15.40
8	15.80
9	16.30
10	16.80
11	17.50
12	18.18
13	18.70
14	19.36
15	19.88
16	20.40
17	20.85
18	21.22
19	21.60
20	21.65

Figure 1.0

In this investigation I will examine a variety of functions to mathematically predict the fluctuations for the 'average' American female's body mass index. The parameters that are used in this graph are the Age which is represented in years and will be the X-Axis on the graph, and the BMI(Body Mass Index) which is given to 4 significant figures and will be placed on the Y-Axis. Although not listed, there are a variety of variables that can affect one's BMI the most common ones being race, genetics , eating habits and environmental factors/variables.

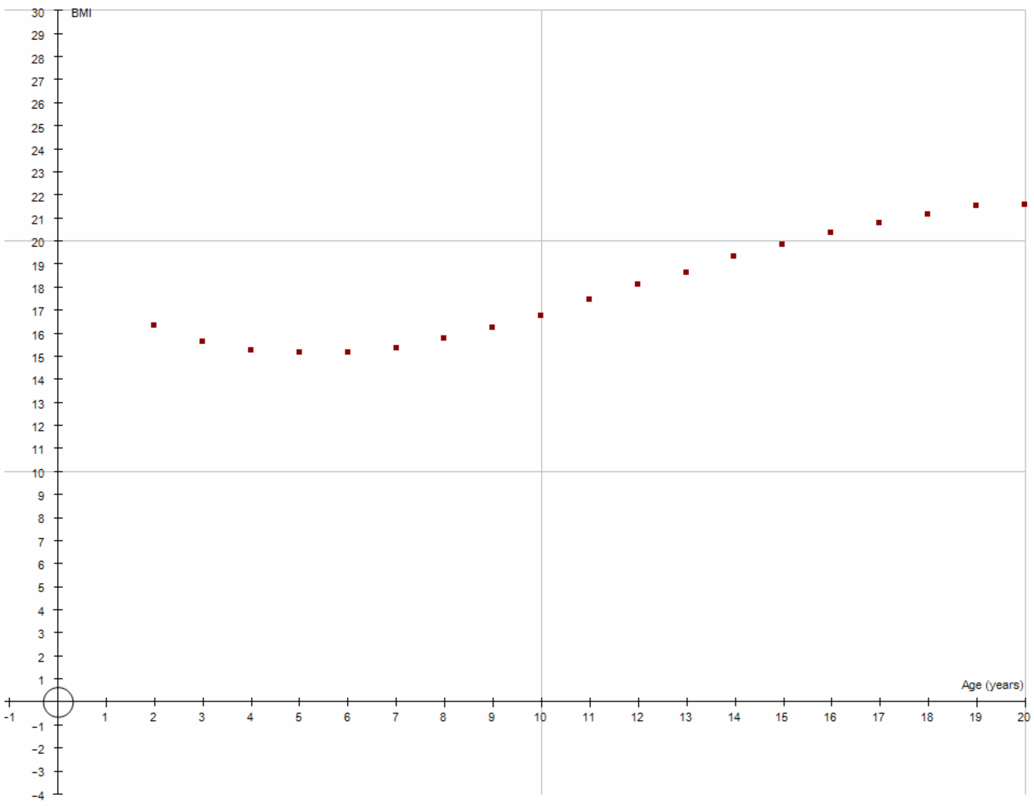

Figure 1.1 *Here is the graph, with the data points from the table above.*

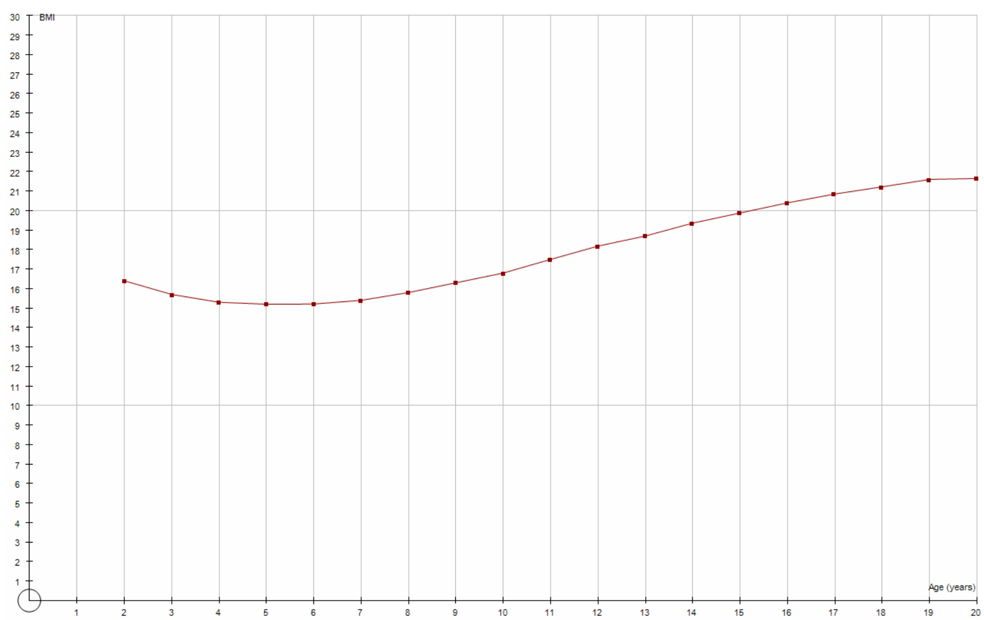

Figure 1.2 *Here is the graph with the points joined up.*

By observing the nature of the curve it is possible to deduce the function that model s the graph. From ***Figure 1.2*** we can observe that the graph is clearly not linear, since it is not straight. It is not exponential or a quadratic either since we can examine the curve growing and then declining towards the end of the graph. Therefore the on ly function models suitable enough for the graph are Cubic, Quartic, Quintic, Sine and Gaussian.

I have chosen the Quintic function because it fits the data points of **Graph 1.1** relatively closely, therefore making it a rather accurate and reasonable funct ion for the range of this data.

The equation for a Quintic function is :

$$A + Bx + Cx^2 + Dx^3 + Ex^4 + Fx^5$$

By using the curve fit equation on **Graph 1.1** and then selecting the Quintic equation I was able to determine the values for A, B, C, D, E, F using Logger Pro.

$$A = 18.81$$

$$B = -1.591$$

$$C = 0.2069$$

$$D = -0.007266$$

$$E = 4.34\ E - 005$$

$$F = 9.787\ E - 007$$

Auto Fit for Data Set | BMI
y = A+Bx+Cx^2+Dx^3+Ex^4+Fx^5
A: 18.81 +/- 0.2414
B: -1.591 +/- 0.1716
C: 0.2069 +/- 0.04164
D: -0.007266 +/- 0.004472
E: 4.343E-005 +/- 0.0002184
F: 9.787E-007 +/- 3.957E-006
RMSE: 0.04725

Figure 1.3 *Values used for the Quintic equation as produced by Logger Pro.*

After obtaining the values for each part of the equation, I input the equation and values into Autograph to create a smoother, more accurate and easier to observe graph.

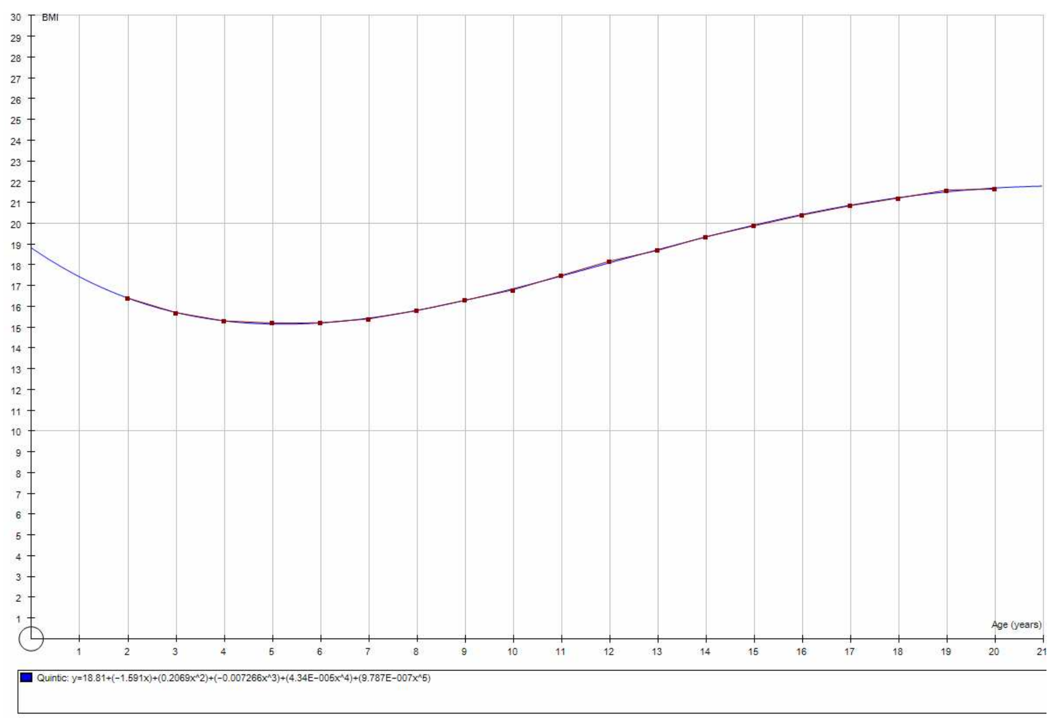

Figure 1.4 *Quintic function produced on Autograph, with original graph.*

The original graph is highlighted in purple, while the model function I have chosen is highlighted in blue. As you can see there are hardly any differen ces, with the current range of data(2 years to 20 years old). However I am positive that if more data concerning the BMI of American women were given, they would not match the Quintic model I have derived.

From the suitable functions listed previously for this type of data (Quartic, Quintic, Cubic , sine and Gaussian), I decided to model the Gaussian since it fits with the original data very accurately as well as the Quintic modeled data, thus making it an appropriate choice.

The equation for the Gaussian function is:

$$A \times \exp\left(-\frac{(x-B)^2}{C^2}\right) + D$$

By using the curve fit function on Logger Pro for the Gaussian equation I was able to determine the values of A, B, C, D.

$$A = -6.933$$

$$B = 5.510$$

$$C = 8.846$$

$$D = 22$$

Auto Fit for Data Set | BMI
y = A*exp(-(x-B)^2/(C^2))+D
A: -6.933 +/- 0.09008
B: 5.510 +/- 0.07125
C: 8.846 +/- 0.1846
D: 22.15 +/- 0.09731
RMSE: 0.08161

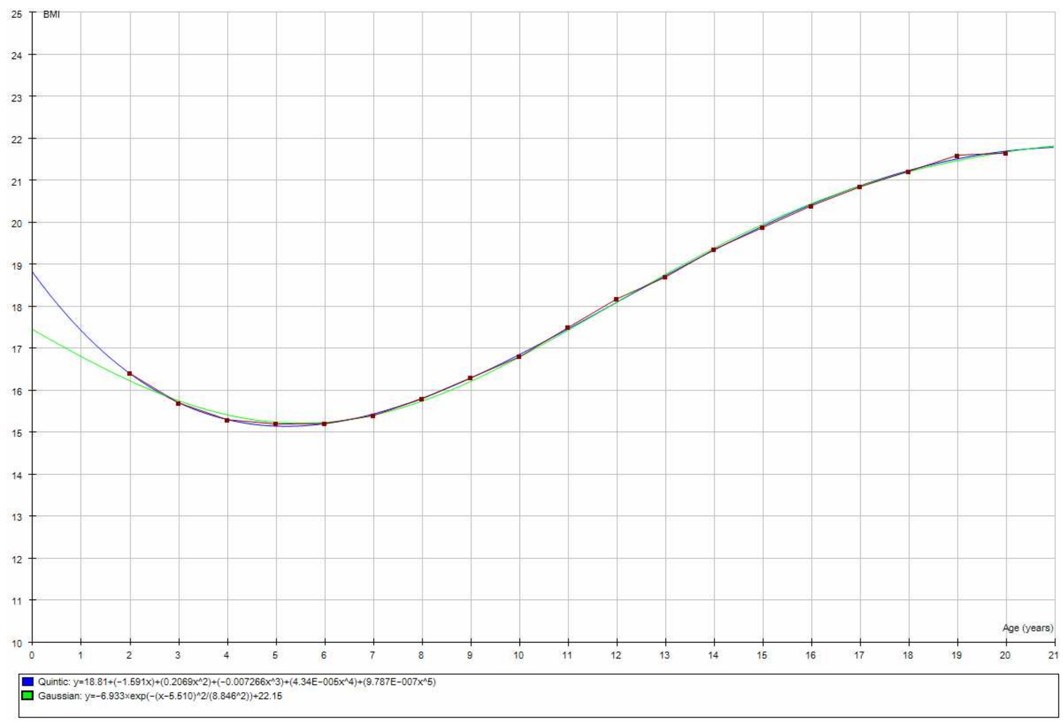

Figure 1.5 *Values for the Gaussian Equation as produced by Logger Pro.*

Figure 1.6 *Gaussian Function produced on Autograph, with Quintic Functi on and Original graph.*

The green curve represents the Gaussian function while, the blue curve remains the Quintic function; with the purple line representing the original graph. There are hardly any differences for this current range of data between the Q uintic and the Gaussian function, however I predict that as the age increases the differences between the Quintic and Gaussian function will definitely increase greatly.

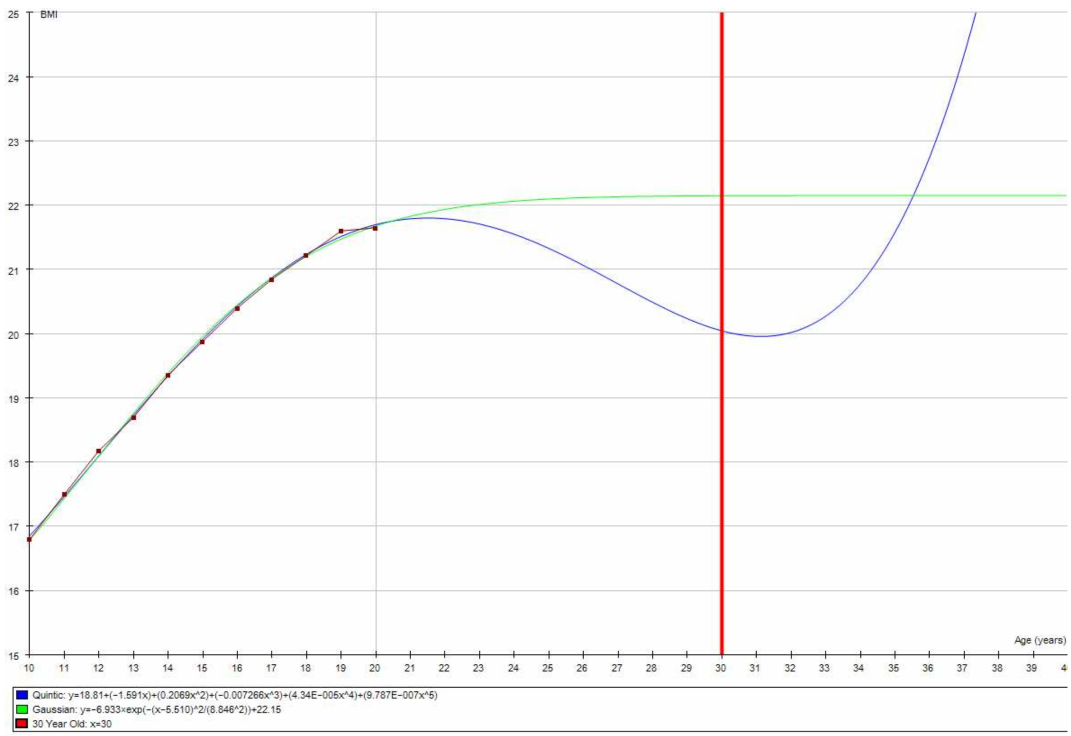

Figure 1.7 *Graph displaying the predicting BMI of a 30 year old American wo man.*

To estimate the BMI of a 30 -year-old woman in the US, I plotted all three graphs (original graph, quartic graph and Gaussian graph), as well as the equation $x = 30$, to find the intersect thus allowing me to interpret the BMI of a 30 -year-old woman according to my function models. The quartic model gives me an answer of $\approx$20, while the Gaussian function gives me an answer close to $\approx$22. While the difference is not huge, it is observable that the Quartic function increases e xponentially as the x -axis increases, thus making it an invalid BMI model. The Gaussian function is closer to predicting the BMI of a 30 -year-old woman since it is 22, which is neither too high or too low and fits reasonably well with the data. As the Gaussian function extends over the years, I would say it is fairly accurate due to the fact that as you grow older your height decreases and your weight either increases or decreases thus making the average BMI in a country relatively similar throughout the ye ars.

To test the comprehensiveness of my function model, I foun d data concerning the BMI of females from another country; China.

Age (years)	BMI
1	16.4
2	16.0
3	15.5
4	15.0
5	14.7
6	14.6
7	14.8
8	15.1
9	15.6
10	16.2
11	16.8
12	17.5
13	18.3
14	18.9
15	19.4
16	19.8
17	20.1
18	20.2

Figure 1.8 *Displays the BMI of urban girls in China in 1995.*

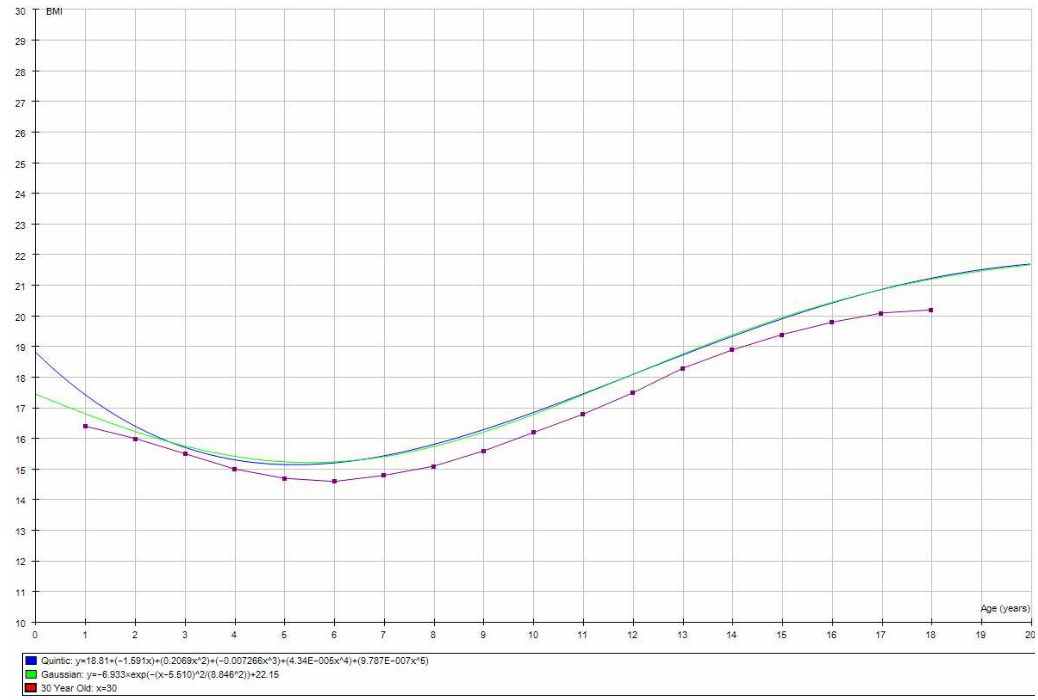

Figure 1.8 *BMI of urban Chinese girls, modeled with the Quartic and Gaussian Function.*

I think my model fits this data reasonably well, altho ugh there are a few minor hiccups. After reviewing the data from women in the US and girls from China, it is safe to say that the quartic and Gaussian function are reliable enough to model their BMI from age 1 to 20. However anything after that is unsure o f. There are a few reasons why the data from girls in China does not match those of the curves of the model such as the data being taken from the year 1995 In comparison to the year 2000 for the American women. The girls/women from China are also not divid ed into one group, however they are separated into two groups; urban girls and rural girls, thus making it slight inaccurate and difficult to compare. The variables of the girls are not known as well, which also make It hard to contrast. To make the model match the data of the girls from China, a simple shift down the Y -axis would have to be made, therefore connecting the girls from China data on to the quintic and Gaussian model.