Investigating the affect that Body Mass Index and Waist-to-hip Ratio has on the Perception of Female Attractiveness.

Abstract

The perception of the attractiveness of women is influenced by two major contributing factors the Waist-to-Hip ratio (WHR) and the Body Mass Index (BMI). It was concluded that at first, WHR was the more influential of the two, however after further investigation and more accurate regression analysis BMI was the more influential. However, together they only resulted in under 50% of the variance, suggesting that there are many other contributing factors that influence the perception of female attractiveness.

Introduction

The Body Mass Index (BMI) is a ratio between the height and weight of a person, calculated by the weight of the person (in kilograms) by their height squared (in metres). Waist-to-Hip Ratio (WHR) is considered to be the factor that signals female fertility and health. This is because healthy, premenstrual women deposit fat on their lower body parts resulting in a feminine characteristic, whereas males deposit fat on their upper body parts. When considering the influence of WHR, alone, on attractiveness lower values of the WHR are considered to be more attractive, with values between 0.6 -0.7 being maximally attractive. Attractiveness is not only based upon the WHR but also on the BMI. Females with very low BMI values (underweight) and very high BMI values (overweight) are considered to be unattractive, with the middle of the BMI value range considered to be attractive and healthy. However, it is that influences of both these factors have upon the perception of attractiveness that has lead to research. Many experiments have been conducted in order to understand which of these two contributing factors are more important in the perception of female attractiveness. Findings by Devendra Singh (1994) conclude that both men and women judged heavier female images with low WHRs as more attractive and healthier than thinner images with higher WHRs. These results show that both the WHR and BMI are considerable contributing factors to the perception of attractiveness. The ideal image has stemmed many other research ideas and it has been found that women chose thin female figures as ideal and perceive their own figure as fatter than the ideal (Fallon and Rozin 1985, cited in Singh 1994). Also, women choose their ideal figure to be much thinner than what they believe to be men's perception of attractive (Fallon and Rozin 1985, cited in Singh 1994). Studies have lead to the assumption that the WHR and BMI influence different aspects of images that all amalgamate into the perception of how attractive that image is. BMI seems to be more influential in the perception of youthfulness (Singh 1994) and studies have found that WHR could be related to fertility and the tendency to give birth to males, rather than females (Tovee & Cornelissen, 1999).

Previous studies have indicated that the BMI is the more influential factor in the perception of attractiveness accounting for more than 70% of the multiple regression analysis where WHR accounts for just 2%. This would suggest that the result of this experiment would be similar and that BMI is the more important contributing factor. However, as mentioned previously, Singh (1994) concluded that women judge perception of attractiveness taking into account the WHR more than the BMI. It has been suggested that in modern society a premium has been placed on thinness and thus it has resulted in the general assumption that 'thin is attractive'. This has certainly been the case in more Westernized civilisations where low WHR is preferred. However, in more traditional societies a higher WHR is preferred as higher WHR is related to the reproduction of sons. So, in societies that value sons over daughters a more 'tubular' shaped women is preferred. This may also be due to the media's representation of attractive, which in many societies is thin, thus partly explaining the obsession with dieting and the struggle to become thin. This brings notice to the problems of eating disorders and how they affect an individual's perception of attractiveness. Morris *et al* (1989) found that over a 20 year period (1959-1978) the weight of Miss America Pageant contestants and Playboy centrefolds significantly decreased. However, it was also found that average waist size increased and bust and hip size decreased, resulting in a more 'tubular' shaped woman. The overall conclusion was that over the last three decades a significant change in the idealized female body shape has occurred. However, later studies showed that Morris *et al* results were inaccurate and that when the actual WHRs were computed they remained within a feminine 0.68-0.72 range thus, clearly showing that the subjects were not becoming a more 'tubular' shape (Singh 1994).

Hypothesis:

BMI will be significantly more important than WHR in determining the attractiveness of a female body.

Null Hypothesis:

There will be no significant difference between the BMI and WHR in determining the attractiveness of the female body

Method

Apparatus: The only apparatus involved was the actual computer programme. The computer programme involved a number of images of the shape of the female body. These images were in black and white and the figure wore a skin tight leotard. The faces were 'blurred' out so there was no bias in the attractiveness of the facial features.

Subjects: The entire psychology class took place in the experiment. The gender of the group was mixed. Although a large proportion of the class was female. The age of the stage two students was predominantly between 19-22 years of age. They were naïve in the intended outcome of the study at this point.

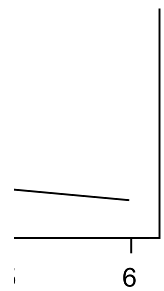
Procedure: The Body Mass Index (BMI) and the waist-to-hip ratio were being investigated. The subjects were presented with a series of 50 female images in front view on a VDU screen. The images varied in Body Mass Index and in waist-to-hip ratio. The subjects were then asked to rate each image on a scale of 0-9, typing their rating into the computer. The first time the subjects went through a practice run so that they could gage their general idea for the ratings. The second time the results were counted and saved, and pooled together with the rest of the class's results.

Results

Graph 1: Scatter plot of the relationship between attraction (a) and the Body Mass Index (b). This shows that the data has no real relationship and appears to be random.

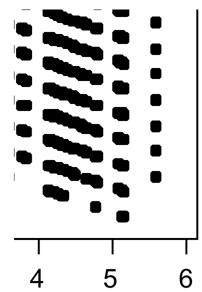
Graph 2: Scatter plot of the relationship between attraction and the Waist to Hip Ratio (h). This also shows that there does not seem to be any apparent relationship between the data and is random.

Graph 3: The relationship between attraction and BMI using the average attractiveness rating for the BMI (abg) and the group values (gval). This shows that images with either extremely high BMI values (overweight) or extremely low BMI values (underweight) are considered to be unattractive, whereas, images with an optimum BMI value are considered to be normal and attractive. This gives the graph an apparent parabola shaped curve.



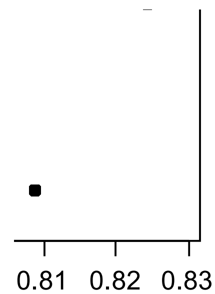
Graph 4: The relationship between the average attractiveness rating for the WHR (ahg) and the group values. This shows that as image's WHR increases, the average attractiveness rating decreases, suggesting that subjects find low WHRs more attractive. This gives the data a linear relationship.

Graph 5: Dotplot for the attractiveness rating Residuals showing that they are roughly normally distributed; there are only a few outliers. This allows for a valid regression analysis.



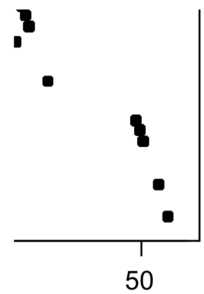
Graph 6: Showing that the distribution of the residuals and the fitted values is roughly linear, but there is a high amount of variance.

Graph 7: The residuals for the WHI showing that they too are roughly normal, about zero and there are fewer outliers. Regression analysis is valid.



Graph 8: This could be considered as a linear relationship between the WHI residuals and fitted values, however this also has a large variance as the data is spread quite widely on the graph.

Graph 9: BMI residuals are also approximately normally distributed, but have some extreme outliers. Regression analysis is valid.



Graph 10: The residuals and fitted values for the BMI are clearly not linearly related. This does not allow a simple linear regression analysis to be applied to the data. The shape of the curve is roughly a parabola, so the regression equation will have to be in the form of:

$$Y = aX - bX^2 + c$$

So, in order to prove this, values of Y were calculated where X takes the values 1 to 20. This formula was used:

$$Y = 20X - X^2$$

The values found for Y and the values for X were then plotted against one another:

Graph 11: Values found for Y when using the values 1 to 20 for X, giving a much smoother parabola than in graph 3. This has given a curvilinear fit rather than straight lines joining up the points.

Predictor	Coef	SE Coef	T	P
Constant	4.2400	0.5032	8.43	0.000
b	0.64483	0.01887	34.17	0.000
h	-9.5179	0.5275	-18.04	0.000
b2	-0.0136965	0.0003609	-37.95	0.000

Table 1: The values of the regression coefficients and their significance. They are all highly significant.

The regression equation is:

$$a = 4.24 + 0.645\, b - 9.52\, h - 0.0137\, b^2$$

The standard deviation and the R-sq value are below:

S = 2.218 R-Sq(adj) = 29.0%

This shows that only 29% of the variance of the data is explained by all three predictor values, BMI, WHR and BMI^2.

Source	DF	SS	MS	F	P
Regression	3	12902.8	4300.9	874.55	0.000
Residual Error	6407	31508.8	4.9		
Total	6410	44411.6			

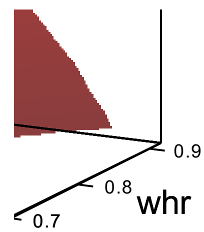
Table 2: Analysis of variance table gives the F-ratio to be 874.55, which is highly significant (P< 0.0005) suggesting that BMI and WHR contribute highly to the attractiveness rating.

Response is a

Vars	R-Sq	R-Sq(adj)	C-p	S	b	h	b 2
1	9.8	9.8	1739.8	2.5003		X	
1	8.6	8.6	1846.1	2.5165			X
2	25.4	25.4	327.6	2.2731	X		X
2	16.1	16.1	1169.4	2.4110		X	X
3	29.1	29.0	4.0	2.2176	X	X	X

Table 3: Best Subsets table with a being the response explained by the three predictors: WHR, BMI, BMI^2. WHR is the best predictor for attractiveness, as it accounts for 9.8% of the scatter, with the BMI^2 being the second best predictor.

The Regression equation (shown below table 1) gives a relationship between the WHR, BMI and the attractiveness rating. This relationship can be shown by calculating the values of Y (attractiveness rating) for all the values of both the BMI and the WHR. This can be plotted in a graph; however there are three variables so a 3D plot has been used.



Graph 12: 3D surface plot of the WHR, BMI and attractiveness rating. The relationship between the BMI and the attractiveness is always curved, however, the height and elevation of the curve always depends upon the WHR. The values are greatest for attractiveness where WHR is high and the BMI is in the middle of the range.

As the previous regression analysis only accounted for 29.0% of the variance (table 1) using a quadratic formula a cubic formula might be a closer representation of the distribution of the data. So, a regression analysis of a cubic formula has been applied:

Predictor	Coef	SE Coef	T	P
Constant	-20.4811	0.6960	-29.43	0.000
h	-6.6310	0.4626	-14.34	0.000
b	3.65640	0.06798	53.79	0.000
b2	-0.136253	0.002703	-50.41	0.000
b3	0.00152751	0.00003346	45.65	0.000

Table 4: The values of the regression coefficients and their significance. They are all highly significant.

The regression equation is

$$a = -20.5 - 6.63\,h + 3.66\,b - 0.136\,b2 + 0.00153\,b^3$$

The standard deviation and R-sq is below:

S = 1.927 **R-Sq(adj) = 46.4%**

This shows that more of the variance is explained (R-sq = 46.4%) when using a cubic formula to predict the attractiveness using BMI and WHR.

Source	DF	SS	MS	F	P
Regression	4	20636.3	5159.1	1390.05	0.000
Residual Error	6406	23775.3	3.7		
Total	6410	44411.6			

Table 5: Analysis of variance table gives the F-ratio to be 1390.05, which is more highly significant suggesting that BMI and WHR contribute highly to the attractiveness rating.

Response is a

							b	b
Vars	**R-Sq**	**R-Sq(adj)**	**C-p**	**S**	**b**	**h**	**2**	**3**
1	11.4	11.3	4199.8	2.4784				X
1	9.8	9.8	4388.1	2.5003		X		
2	25.4	25.4	2516.2	2.2731	X		X	
2	20.9	20.8	3064.6	2.3419	X			X
3	44.7	44.7	208.5	1.9570	X		X	X
3	29.1	29.0	2086.7	2.2176	X	X	X	
4	46.5	46.4	5.0	1.9265	X	X	X	X

Table 6: Best Subsets table with a being the response explained by four predictors: WHR, BMI, BMI^2 and BMI^3. BMI^3 is the best predictor for attractiveness, as it accounts for 11.3% of the scatter, with the WHR being the second best predictor. Using a cubic has changed the best predictor from the WHR (table 3) to the BMI^3. This suggests that the BMI is now the more important contributing factor.

As using a cubic formula has increased the accuracy of predicting the attractiveness it may be even more accurate using a power of 4.

Predictor	Coef	SE Coef	T	P
Constant	-44.917	1.586	-28.31	0.000
h	-6.5142	0.4525	-14.40	0.000
b	7.9719	0.2617	30.47	0.000
b2	-0.40244	0.01583	-25.42	0.000
b3	0.0083493	0.0004014	20.80	0.000
b4	-0.00006180	0.00000362	-17.05	0.000

Table 7: The values of the regression coefficients and their significance. They are all highly significant.

The regression equation is

a = - 44.9 - 6.51 h + 7.97 b - 0.402 b2 + 0.00835 b3 -0.000062 b4

The standard deviation and R-sq is below:

S = 1.884 R-Sq(adj) = 48.8%

This again, has increased the accuracy of predicting the attractiveness rating. 48.8% of the variance is now explained.

Source	DF	SS	MS	F	P
Regression	5	21668.8	4333.8	1220.51	0.000
Residual Error	6405	22742.8	3.6		
Total	6410	44411.6			

Table 8: ANOVA using the power of 4 formula. The variance ration has further increased (1220.51) making it more highly significant.

A best subset table was attempted using the predictors; b, h, b^2, b^3 and b^4 however, it was not possible as it was too highly correlated. This suggests that it is the BMI that is the more important influence on attractiveness.

Discussion

The data at first seemed to be random (graphs 1and 2), however when the average attractiveness rating using the BMI (graph 3) and the WHR (graph 4) were plotted against their categorised groups from 1 -6:

BMI Score	Category
below 15	emaciated
15-19	underweight
19-24	acceptable
24-30	overweight
30-35	obese
35 plus	very obese

WHR
below 0.6
0.6-0.73
0.73-0.77
0.77-0.81
0.81-0.85
0.85 plus

It can be seen that the relationship is linear between the WHR, i.e. the lower the WHR value the more attractive the image is considered to be. Whereas, the BMI the data is not linearly related and that the lower the BMI score the image seems to be unattractive and the higher the BMI score the image is also considered to be unattractive. As the BMI is not linearly related a quadratic formula had to be used in order to better predict the rating. Therefore the residuals had to be analysed in orde r to justify this. Graphs 5 and 6 show the distribution of the residuals for the attractiveness rating and the relationship of them with the fitted values, respectively. The residuals were distributed normally and the relationship seemed linear, but seemed to have a high variance. Similarly with the residuals of WHR (graphs 7 and 8), residuals were normally distributed and an approximate linear relationship with the fitted values. However, the residuals for the BMI, although normally distributed (graph 9), did not have a linear relationship with their fitted values (graph 10). So a quadratic formula was used which resulted in a much smoother parabola (graph 11) showing the same relationship from graph 3 but more clearly.

As all the residuals were approximate ly normally distributed regression analysis was valid and applied (table 1) using the quadratic (BMI^2) as one of the predictors. This resulted in only just under 30% (R -sq = 29.0%) of the variance being explained by the three predictors. This was probably due to other contributing factors that were not taken into account during the experiment such as the gender of the subjects, cultural differences e.t.c. An analysis of the variance was applied and resulted in a very highly significant variance ratio (874.55) suggesting that both the BMI and WHR were significant contributing factors. The first table of best subsets (table 3) shows that the WHR is the more influential of the two factors. However, only 29% of the variance has been explained and this is not muc h, so could be inaccurate. So, a cubic formula was tried and this resulted in a more accurate regression equation (table 4) and a greater proportion of the variance was explained (46.4%). The best subsets (table 6) showed that the BMI was the best

contributing factor with the WHR second. The analysis of variance (table 5) confirmed that the significance of the two factors in predicting the attractiveness rating had increased (variance ratio = 1390.05). The same test was done to discover if using a formula with the power 4 would make a more accurate predictor. This was true and R-sq = 48.8%, so the accuracy was beginning to plateau off at around 50%. The best subsets of the power four attempted, however was impossible to compute as the correlation was too high.
Using firstly, the quadratic allowed a relationship between the three values WHR, BMI and attractiveness to be formulated and plotted against one another (graph 12). This shows that the relationship between the BMI and the attractiveness is always curved, however, the height and elevation of the curve always depends upon the WHR. The values are greatest for attractiveness where WHR is high and the BMI is in the middle of the range. This contradicts graph 4 where the lower the WHR the more attractive the image is considered to be. However, graph 4 only takes into account the influence of WHR alone, not the joint influence of both factors together like graph 12.

Greater information could be been obtained if the subjects were asked their gender before rating the images. This would have allowed insight into whether males perception of attractiveness if different to that of women's. Also the age of the subjects could have been varied to see if the age of the individual has an affect on their perception of attractiveness. This has been researched by Fallon and Rozin (1989, cited in Singh 1994) as women's perception is thinner than that of men's ideal. This also works the opposite way, as the age and gender of the images could have been varied to see if either one has an effect upon attractiveness. Cultural differences both of the subject and of the image should be investigated. If the culture of the subject influences their perception, or if, for example, the colour of the person in the image matters to the subject. Are coloured people considered to be less, more or indifferent in their attractiveness to other different coloured people? Also, geographical differences, whether the ideal image of attractiveness varies between the populations of different countries. Yu and Shepard (1998, cited in Tovee & Cornelissen 1999) have investigated this and among their findings concluded that Americans prefer higher WHRs to the English. Possibly a more important and more interesting factor could be eating disorders and the effect that they have upon the individual's perception of attractiveness. With the media's representation and obsession with supermodels there has been a steady increase of eating disorders among the population. This rise was predicted by the studies of Agras (1987 cited in Morris *et al* 1989) when the change in the body shape of women began to appear in fashion magazines.

To conclude at first the WHR seemed to be the more important contributing factor (table 3) however, when using a cubic and the power of 4 the accuracy began to increase and it became apparent that the BMI was quite considerably the more influential of the two factors (BMI = 11.3% and WHR = 9.8%). This is supported by other research; however, there are many other contributing factors such as , age, culture and eating disorders, which need further investigation.

References

Morris, A. et al (1989). The changing shape of female fashion Models. *Journal of Eating Disorders.* ***8:*** 593-596**.**

Singh, D. (1994) Ideal female Body Shape: The role of body weight and Waist-to-Hip Ratio. Journal of Eating Disorders **16:**283-288**.**

Singh, D. (1994) Is thin really beautiful and good? Relationship between Waist-to-hip ratio (WHR) and female attractiveness. *Personal and Individual Differences* **16:** 123-132

Tovee, M.J. & Cornelissen, P.L (1999). The mystery of Female beauty *Journal of Nature* 399, 215-216