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Model for Human Waist Size Estimation and the Recommended Pharmaceutical Tolerable Range for Humans (A Study of Federal University Wukari, Nigeria's Campus Community)

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Abstract

This research is concerned with the development of a mathematical model for estimating the Waist size of humans in relation with their height and weight. The model was validated in order to very whether it could estimate what it was created to measure by comparing the estimations of the model and the real-life sourced data from the study area. But, the outcome of the model's validation revealed that the model's data predictions are in strong agreement with the real life measurement with a correlation coefficient of 0.96796 and thus recommends the model as a standard model for estimating the waist size of humans.

Keywords: Body weight, Height, Waist size, Nigerians, Correlation coefficient, Model equation constants

INTRODUCTION

In recent times, health insecurity/challenges have murdered more human lives than wars and communal violence and crises [1,7] Thus, addressing insecurity as a nation demands that health insecurity/challenges should be prioritised. This undoubted reality is what gave birth to the motivation for this research work.

However, the measurement of body parts has been used at different age categories, as a sensitive indicator of wellness, maturation and development in humans. This measurement is also known as Anthropometrics [5]. Anthropometrics measures is the single most universally applicable, inexpensive and non-invasive method available for the assessment of size, proportion and composition of human body [1,2]. Height and weight are the two most easily obtained anthropometric measures and have been used extensively in screening and monitoring programs because abnormal weights categories (underweight, overweight and obesity) have been considered as risk factors for various diseases [3].

Notwithstanding, the study of waist size estimation can be useful for determining a significant health measurement index known as Body mass index (BMI). The human BMI can be utilised to calculate weight of humans in kg/height in m^2. At present, the BMI is the most often used and widely satisfactory methods of distribution of body weight and classification of medical risk [4]. BMI is a useful determinant of adiposity in early and middle-aged adults [4]. However, an important restriction of BMI is its inability to recognize between fat mass and fat-free mass, which is a good indicator of health status [6].

In addition, the robustness of BMI as an indicator of fatness in advanced adulthood is limited [7]. This is because the fat-free mass reduces with aging, without a change in overall weight [8]. In contrast, waist circumference represents a measure of adiposity that takes into account the assemblage of abdominal fat. [4]. Thus, obesity is easier to measure and interpret using the waist circumference allocution.

METHODS

Under this section, we considered the following subheadings like: Model formulation, Basic assumptions for the model, establishment of relationship between our model parameters, and evaluation of the resulting model equations' constants.

Formulation of the Model

In similar manner, this subsection will also address the following subtopics as they unfold.

Basic assumptions

Waist size (W_S) versus Weight (W)

A man, who uses his waist belt calibrated at a certain 38cm mark on the tape measure, has his initial weight to be very large (in value) as at the time of this research noted to be x_1. After a short while since he became uncomfortable with his state decided to embark on slimming down activities. And consequently, due to (rigorous dehydration process, burning of calories, hunger, and so on), he was able to lose some pounds of weight, and his belt calibrated at the 38cm mark which is his initial waist size, (W_S) could not fit him or stick properly to his wais anymore as it was initially. Hence for a perfect comfort and fitness in his dressing, he reduced his belt calibration `to yet another 32cm mark in order for his belt to fit/size him. But when his waist size (W_S) got reduced, he went and take a new measurement of his weight (W) and discovered that his body weight has likewise reduced in kg to another value x_2. Thus it can be postulated that, the waist size (W_S) of a person is directly proportional to his weight (W) since a decrease in one leads to a corresponding decrease in the other; and vice versa. Hence mathematically,

$$W \propto W_S;$$

$$\Rightarrow W = k_2 W_S \tag{2.1}$$

2.1.1.1 Waist-size versus Height

From the findings of the work of Ogwumu *et al.* (2014), it can be deduced that the height, H of a human being is directly proportional to his weight, W. Hence mathematically,

$$H \propto W$$

$$\Rightarrow H = k_2 W \tag{2.2}$$

But also from equation (2.2)

$$\left.\begin{aligned} W &= k_3 H \\ where:: \ k_3 &= \frac{1}{k_2} \end{aligned}\right\} \tag{2.3}$$

But putting (2.3) into (2.1) gives;

$$W = k_1(k_3H) = k_1k_3H \quad (2.4)$$

Again putting (2.3) into (2.4) yields,

$$W_S = \frac{k_1}{k_2}H \quad (2.5)$$

2.1.3 Waist size (W_S) versus a Constant Term Representing Other Parameters not considered

$$\therefore W_S = d \quad (2.6)$$

First establishment of model parameter relationship

From our respective postulations above, adding equation (2.1), (2.5)and (2.6) gives

$$\therefore W_S = \frac{1}{2}\left[k_1W + \frac{k_1}{k_2}H + d\right] \quad (2.7)$$

Hence using the following substitutions, we have,

$$\left.\begin{aligned} &\therefore W_S = \phi W + \xi H + \sigma \\ &where: \phi = \left(\frac{k_1}{2}\right), \\ &\xi = \frac{k_1}{2k_2} \\ &and \quad \sigma = \frac{d}{2} \end{aligned}\right\} \quad (2.8)$$

Where; H = Height of an Individual

W_S = Waist size of an Individual

W = Weight of an Individual

σ, ϕ and ξ are the Model constants to be determined.

Analysing the Model to Evaluate its Equation Constants

To evaluate the constants in the model above, equation (2.8) is going to be differentiated partially with respect to $\sigma, \phi\ and\ \xi$ respectively. To do this, we have to minimize the model using *least squares method* as follows: From (2.7) we let,

$$\left.\begin{array}{l} Z_{\min} = \min \sum (W_{S\,i} - \phi W_i - \beta W_i - \sigma)^2 \\ \quad i = 1,2,3...............n \end{array}\right\} \quad (2.9)$$

$$\frac{\partial Z}{\partial \phi} = -2\sum (W_{S\,i} - \phi W_i - \xi H - \sigma) W_i = 0 \quad (2.10)$$

$$\frac{\partial Z}{\partial \xi} = -2\sum (W_{S\,i} - \phi W_i - \xi\ H_i - \sigma) H_i = 0 \quad (2.11)$$

$$\frac{\partial Z}{\partial \sigma} = -2\sum (W_{Si} - \phi W_i - \xi H_i - \sigma) = 0 \quad (2.12)$$

Hence from (2.10)

$$-2\sum (W_{S\,i} - \phi W_i - \xi H - \sigma) W_i = 0$$

$$(2.13)$$

$$\therefore\ \phi \sum W_i^{\ 2} + \xi \sum W_i H_i + \sigma \sum W_i = \sum W_{Si} W_i \quad (2.14)$$

Also from (2.11)

$$-2\sum (W_{S\,i} - \phi W_i - \xi\ H_i - \sigma) H_i = 0 \quad (2.15)$$

$$\therefore\ \phi \sum H_i W_i + \xi \sum (H_i)^2 + \sigma \sum H_i = \sum H_i W_{Si} \quad (2.16)$$

Hence from (2.12)

$$-2\sum (W_{Si} - \phi W_i - \xi H_i - \sigma) = 0 \quad (2.17)$$

$$\therefore\ \phi \sum W_i + \xi \sum H_i + 10\sigma = \sum W_{Si} \quad (2.18)$$

i = 1, 2, 3, …, n. But, for this research, n = 10.

Meanwhile Equations (2.14), (2.16) and (2.18) are to be solved simultaneously for values of $\sigma, \phi\ and\ \xi$ respectively.

Research instrument used

The research instrument used is known as the random sampling technique. This is a situation where a certain sample of the Taraba State's community members was randomly made to represent the entire population of the university community for the research. However, during the study, only the set of questionnaires for persons that are not 'deprived' by nature leading to dwarfism, obesity etc were considered. Such natural situation stated above may affect the authenticity of our research model and may not allow the model results to conform to reality. Also, in the questionnaire there are questions designed to checkmate fake responses. Wherever any element of fake response is discovered, the questionnaire is ignored accordingly. Moreover, 150 copies of questionnaire were distributed. But only 10 copies which satisfied our acceptability test were considered. We attached a fake response (F.R.) test/acceptability test to each questionnaire such which any one that became successful was considered for the research.

Table 1. Questionnaire and Measured data gathered from Federal University Wukari Community of Nigeria

Waist size, W_s (inches)	Weight(kg)	Height, H(m)
31.5	65	1.72
31	60	1.68
31	61	1.7
33	63	1.72
32	55	1.58
32	68	1.73
32	68	1.76
32	70	1.77
33	75	1.8
32	80	1.9

Evaluation of the Equation Constants Using the Questionnaire Data in Table 3

Solving equation (2.14), (2.16) and (2.18) in the section above simultaneously, where from the Table1 above,

$$\sum W_i = 665, \sum H_i = 17.36, \sum W_{S\,i} = 319.5, \sum H_i^{\,2} = 30.199,$$

$$\sum (W_i)^2 = 42262,\ \sum W_i W_{Si} = 21264.5,\ \sum W_i H_i = 1159.78,\ \sum W_{Si} H_i = 554.8$$

Using the data collected for equations (2.14), (2.16) and (2.18) we have:

$$44713\phi + 1159.78\xi + 665\sigma = 21264.5 \quad (2.19)$$

$$1159.78\phi + 30.199\xi + 17.36\sigma = 554.8 \quad (2.20)$$

$$665\phi + 17.36\xi + 10\sigma = 319.5 \quad (2.21)$$

Hence, solving (2.19), (2.20) and (2.21) above simultaneously gives,

$$\phi = 0.162342952,$$
$$\xi = -11.58786853,$$
$$\sigma = 41.27073346.$$

Also, putting the values of φ, ξ *and* σ *in equation* (2.8) *yields,*

$$\left.\begin{aligned} \therefore W_S &= 0.162342952W - 11.58786853H + 41.27073346. \\ W_S &\geq 0 \quad or \ W_S \in [0,1) \end{aligned}\right\} \quad (2.22)$$

The model built in equation (2.22) follows the method of model building as shown in the works of [8,9,10]. With equation (2.22), when any value of W and H in table1 is substituted, it was observed that the model's corresponding Waist size prediction in equation (2.22) gives a near-exact approximation to the exact value in the table for all the cases.

2.4 Correlation Coefficient between the Gathered Data and our Model Estimation

Correlation Coefficient $r = \dfrac{n\sum xy - \sum x \sum y}{\sqrt{\left[n\sum x^2 - \left(\sum x\right)^2\right]\left[n\sum y^2 - \left(\sum y\right)^2\right]}}$

r = 0.96796

RESULTS AND DISCUSSION

Validation of our Model

After the model became ready, the researcher conducted a pilot test using data of some people living in Wukari community (the area of the research) to see whether or not the model conforms to reality. The test confirms that the model is suitable for the people since the absolute difference between the model data generated and the actual measurement done for the people is approximately less than two units in all (as shown in Table 3 below). This little difference in measurement however, is due to the fact that, the parameters considered by the researchers are not the whole parameters associated with the study of waist size of human beings.

Similarly, the scenario from the table3 above confirms the view of [5] that, model parameter relationships are inexact. The reason being that, the solution is dependent on the parameters decided to be considered by the modeller. Moreover, the table below gives a validation of the questionnaire data to see whether the model really measures what it claims to measure in order to be able to conclude if the model conforms to reality or not.

CONCLUSION

As mentioned earlier, according to World Health Organisation, health related issues have killed more lives than wars. And since excessive waist size leads to obesity which could generate some more dangerous health risks, then the simple waist size model built in this study as shown in equation (2.22) is recommended to every adult to be used in regular computations of their waist sizes. This is a mini-waist size computation calculator if someone could substitute his/data into the equation (2.22) of this study.

REFERENCES

[1] World Health Organisation (1995). Physical status: the use and interpretation of anthropometry. Available from: http://www.who.int/childgrowth/publications/physical_status/en/index.html. Accessed on: August 2012.

[2] Amuta E, Houmsou RS (2009). Assessment of Nutritional Status of School Children in Makurdi, Benue State. Pakistan Journal of Nutrition;8:691-4.

[3] Knowler WC, Pettitt DJ, Saad MF, et al (1991). Obesity in the Pima Indians: its magnitude and relationship with diabetes. Am J Clin Nutr 53:S1543-51.

[4] Leitzmann MF, Moore SC, Koster A, et al.(2011),Waist circumference as compared with body-mass index in predicting mortality from specific causes. PLoS One; 6:e18582

[5] Shalom Nwodo Chinedu, Olubanke o. Ogunlana, Dominic E. Azuh, Emeka E.J. Iweala, Israel S. Afolabi, Chidi C. Uhuegbu, Mercy E. Idachaba, Victor C. Osamor (2013), Correlation between Body Mass Index and Waist circumference in Nigerian Adults: Implication as indicators of heath status, Journal of Public Health Research; Volume 2:e16, Pg 93-98

[6] Ogwumu O. D., S. A. Amoo, F. Y. Eguda, E. O. Adeyefa and S. Abubakar (2015), A Mathematical Model for Estimating the Weight of Human Beings Using Some Anthropometric Parameters (A Case Study of Taraba State of Nigeria's Community), *British Journal of Mathematics & Computer Science*, 8(2): 147-158,

[7] WHO (2020), The top 10 causes of death, A World Health Organisation's publication retrieved on the 31st July, 2024 from https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death

[8] Ogwumu Onah David., Ovuzonye Samue Ataribu, Osas Samuel Emmanuel, Ganiyu Ajileye, Isaiah Ogwumu, Ruth Omagbu Ikape (2023), Model For Estimating Income-Linked Life Expectancy In West African Countries, August 2023, NED University Journal of Research, DOI: 10.35453/NEDJR-ASCN-2023-0003.R2

[9] Ogwumu O. D, Kyagya TY, Amakoromo GI, Keto KM, Ezeh AT, Ogofotha MO, Elugah JI. (2020a), A Mathematical Model for Predicting Rate of Divorce Tendency in Nigeria: A Study of Taraba State, Nigeria. International Journal of Mathematical Sciences and Computing (IJMSC). 2020, 6(5):15-28.

[10] Ogwumu O. D., Kyagya T. Y, Amakoromo G.I, Keto KM, Ezeh A.T., Ogofotha M. O, Elugah JI. (2020b) Mathematical Model for Predicting the Rate of Human Happiness: A study of Federal University Wukari community of Nigeria. *International Journal of Mathematical Sciences and Computing* (IJMSC). 2020; 6(6):30-41.