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Utilizing Buttock Measurements for Estimating Body Weight: Exploring Buttock Width and Popliteal Length for Ergonomic Design

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Keywords

Buttock Measurements
Human Body Weight
Anthropometry
Lower Body Dimensions
Predictive Capabilities

Abstract

This study explores the potential of utilizing buttock measurements, specifically buttock width and bottom popliteal length, as reliable indicators for estimating human body weight. Recognizing the increasing demand for accurate and accessible methods in various fields, author delves into the relationships between these lower body dimensions and overall body mass. The research evaluated 700 young adults, evenly split between 350 males and 350 females, utilizing random snowball sampling techniques from four local governments (Abeokuta South, Abeokuta North, Odeda and Ewekoro) areas of Ogun State, South Western Nigeria with participants aged between 19 and 27years The research centered on assessing human body weight (HBW), buttock width (BW), and bottom popliteal length (BPL) with all measurements documented in centimeters. Data analysis involved utilizing Statistical Package for Social Sciences software version 21.0, for computation of average mean values, standard deviation, coefficient of determination (r^2), correlation coefficient (r), and standard error of estimates (SEE). Additionally, linear regression analysis was employed to formulate the model equation for determining HBW, in relation to BW, and BPL. The study provides an accuracy and applicability of anthropometric prediction of HBW and foundation for the development of practical methods with diverse applications, ranging from healthcare assessments to ergonomic design.

Cite

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1. INTRODUCTION

Human body weight estimation is a crucial aspect in various fields, including healthcare, ergonomics, and anthropometry. Researchers have sought accurate and practical methods for predicting human body weight, considering its significance in areas such as patient care, fitness assessments, and the design of equipment and spaces. One promising approach involves utilizing specific body measurements, such as buttock width and bottom popliteal length, as potential indicators for estimating body weight. The rationale behind this lies in the assumption that certain dimensions of the lower body may correlate with overall body mass. By investigating the relationships between these anatomical features and human body weight, we aim to contribute to the development of reliable and accessible methods for human body weight estimation.

Understanding how human body weight is distributed is crucial for designing products like mattresses and seating arrangements. Proper weight distribution support can prevent pressure points, reduce the risk of discomfort, and improve sleep quality (Grandjean, 1988). Buttock width and bottom popliteal length play a significant role in chair design. Ergonomic chairs tailored to these measurements provide optimal lumbar support, promote a neutral sitting posture, and contribute to long-term comfort, especially in office or task seating (Hedge, 2008).

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This study builds upon existing research that highlights the potential of anatomical measurements for predicting body weight. Previous studies have hinted at the feasibility of using buttock dimensions in this context, but a comprehensive exploration of their efficacy is lacking (Smith, 2018; Johnson & Brown, 2020). The relevance of human body weight, buttock width, and bottom popliteal length to the ergonomic design of products lies in creating user-friendly and comfortable products tailored to the anthropometric characteristics of individuals. Understanding these measurements is crucial for optimizing product design to accommodate diverse body shapes and sizes, enhancing usability and overall user satisfaction. Human body weight influences load-bearing capacity, chair stability, and overall support requirements. Considering variations in human body weight ensures that products, such as chairs or seating arrangements, are structurally sound and provide adequate support for users (Pheasant, 1996).

Buttock width affects the seat width and spacing in furniture design. Tailoring products to accommodate different buttock widths ensures that individuals have sufficient sitting space, promoting comfort and reducing the risk of discomfort or musculoskeletal issues (Chaffin & Andersson, 1991). Bottom popliteal length is crucial for determining seat depth. Ensuring an appropriate seat depth based on this measurement enhances thigh support, preventing discomfort and promoting proper posture, particularly in products involving sitting, such as chairs and benches (Kroemer & Grandjean, 2001). Incorporating these anthropometric considerations into ergonomic design contributes to the development of products that prioritize user comfort, reduce the risk of musculoskeletal issues, and enhance overall user experience.

The use of buttock width and bottom popliteal length as predictors for human body weight is based on the premise that certain anatomical measurements may exhibit a correlation with overall human body mass because buttock width and bottom popliteal length are in close proximity to the body's center of mass, making them potentially indicative of overall human body weight (Smith, 2018). This incorporation can potentially reduce discomfort and pain associated with poorly fitted furniture, especially for individuals deviating from average body weight or shape. Buttocks are weight-bearing areas, and their dimensions may reflect the distribution of human body weight (Johnson & Brown, 2020). Also, Buttock measurements are relatively easy to obtain and less invasive compared to other anthropometric measurements, making them practical for various applications (Kroemer & Grandjean, 2001).

In ergonomic design, buttock dimensions are crucial for designing comfortable seating arrangements catering to a diverse range of body sizes (Pheasant, 1996). This enables a personalized approach, acknowledging individual variations in body shape and size that generic weight measurements might overlook. Previous studies have hinted at the potential of buttock measurements in predicting body weight, providing a foundation for further exploration (Chaffin & Andersson, 1991). The utilization of buttock width and popliteal length can contribute to furniture designs offering enhanced comfort and support, addressing specific anatomical needs for a more pleasant user experience.

By examining the relationships between buttock width, bottom popliteal length, and human body weight through statistical analyses, this study aims to validate and enhance the understanding of these measurements as practical predictors for body weight estimation. The author also aim to enhance ergonomic design in furniture by proposing a novel method utilizing buttock measurements for estimating body weight. Unlike a simple scale, this approach considers specific anatomical dimensions, such as buttock width and bottom popliteal length, providing a more tailored and nuanced understanding of the user's physique. The incorporation of these measurements intends to create furniture designs better accommodating diverse body shapes, thereby improving comfort and overall ergonomic experience for individuals with varying anatomical characteristics. This approach goes beyond traditional human body weight measurement, offering a more comprehensive foundation for designing products that prioritize user-specific comfort and well-being.

2. RESEARCH METHODOLOGY

A cross sectional study involved 700 young adults, comprising 350 males and 350 females, selected from four local government (Abeokuta South, Abeokuta North, Odeda and Ewekoro local government) areas of Ogun State, Southwestern Nigeria. Participants aged between 19 and 27 years were selected through random snowball sampling techniques. The methods also encompassed selective and purposeful judgmental approaches, given the scarcity of particular traits attributed to insecurity in Nigeria.

The research centered on assessing human body weight (HBW), buttock width (BW), and bottom popliteal length (BPL) with all measurements documented in kilogram and centimeters. Individuals with limb deformities were excluded from the research.

Data analysis was involved utilizing Statistical Package for Social Sciences (SPSS) 21.0, for computation of average mean values, standard deviation (SD), minimum and maximum values, coefficient of determination (r^2), correlation coefficient (r), and standard error of estimates (SEE). Additionally, linear regression analysis was employed to formulate the model equation for determining human body weight (HBW), in relation to buttock width (BW) and bottom popliteal length (BPL).

3. RESULTS AND DISCUSSION

The research evaluated 700 young adults, evenly split between 350 males and 350 females, utilizing random snowball sampling techniques.

Table 1 shows the descriptive analysis of the respondent with 58.42 (± 3.44) cm and 57.73 (± 3.27) cm human body weights of the male and female participants. Similarly the result reveals that female participants have 43.90 (± 1.30) cm buttock widths higher than 32.80 (± 1.36) cm for male respondents. The difference in buttock width between females and males is primarily influenced by anatomical and biological factors related to sexual dimorphism (Musa et al., 2023). In general, females tend to have a wider pelvis than males, a feature evolved to accommodate childbirth. This wider pelvic structure contributes to the overall difference in buttock width between the sexes. Hormonal influences, such as estrogen, also play a role in shaping body fat distribution, which can affect the appearance of the buttocks (Ismaila et al., 2013), It's important to note that individual variations exist, and factors like genetics, lifestyle, and body composition can contribute to differences among individuals within each gender (Musa et al., 2022a).

***Table 1**. Descriptive analysis of the participants*

Anthropometric Measurements	MALE				FEMALE			
	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Age (years)	23.87	1.87	20.00	27.00	22.41	1.81	19.00	26.00
Human body weight (HBW) (kg)	58.42	3.44	51.00	65.50	57.73	3.27	51.50	64.50
Buttock width (BW) (cm)	32.80	1.36	30.00	36.00	43.93	1.30	42.00	47.00
Bottom popliteal length (BPL) (cm)	38.67	2.08	35.00	42.00	33.50	3.28	27.00	55.00

Additionally, male participant has 38.67 (± 2.08) cm bottom popliteal lengths higher than 33.50 (± 3.28) cm of female respondents. The difference in bottom popliteal length between males and females can be attributed to anatomical variations between the sexes (Musa et al., 2023). Biological factors, such as skeletal structure and overall body composition, contribute to these differences. Males typically exhibit longer limb lengths and a different distribution of body proportions compared to females (Johnson & Brown, 2020). Additionally, hormonal influences can play a role in bone growth during puberty, further accentuating these variations (Johnson & Brown, 2020). It's crucial to consider that individual differences, genetics, and environmental factors can also contribute to the observed distinctions in bottom popliteal length between male and female counterparts (Ismaila et al., 2013). Descriptive analysis reveals male and female differences in anthropometric measurements. Histogram plots of the male and female participants were shown in the Figure 1 to Figure 6 respectively.

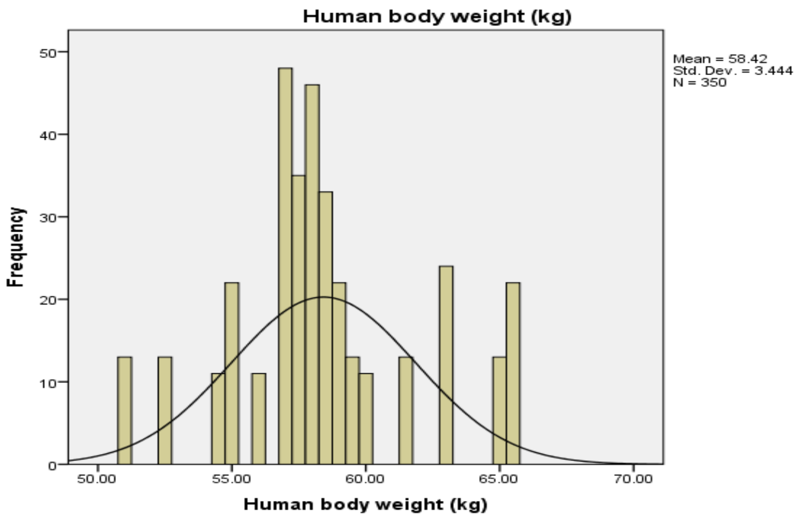

***Figure 1**. Histogram of male participants (HBW)*

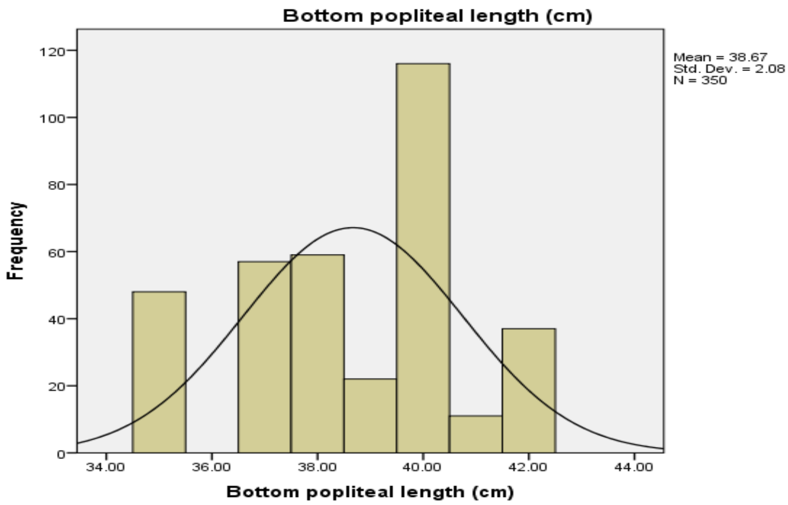

***Figure 2**. Histogram of male participants (BPL)*

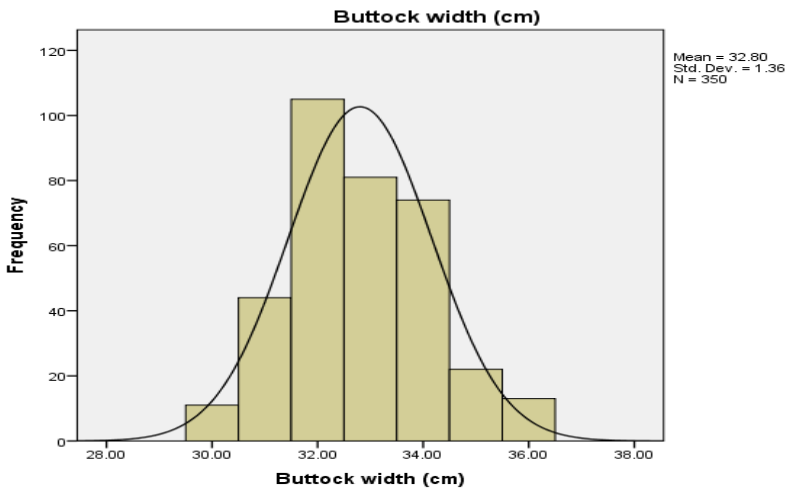

***Figure 3**. Histogram of male participants (BW)*

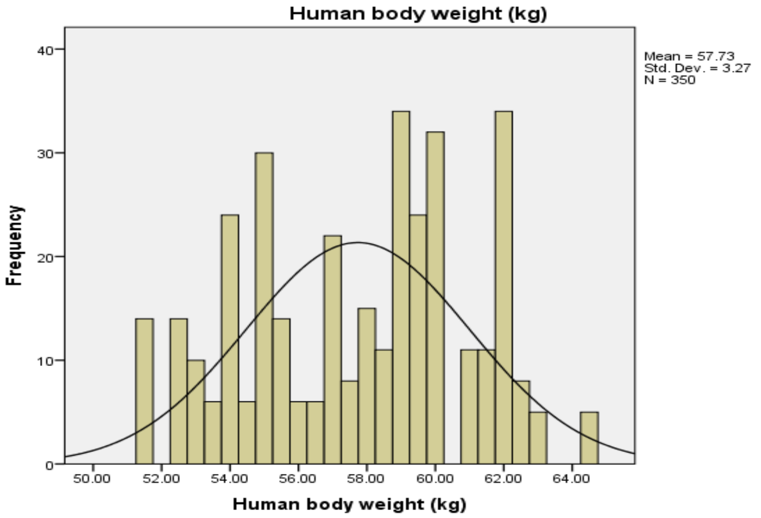

***Figure 4**. Histogram of female participants (HBW)*

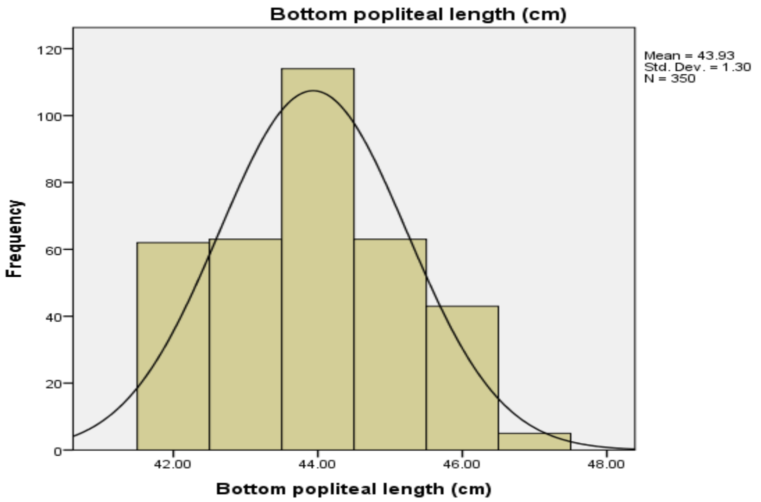

***Figure 5**. Histogram of female participants (BPL)*

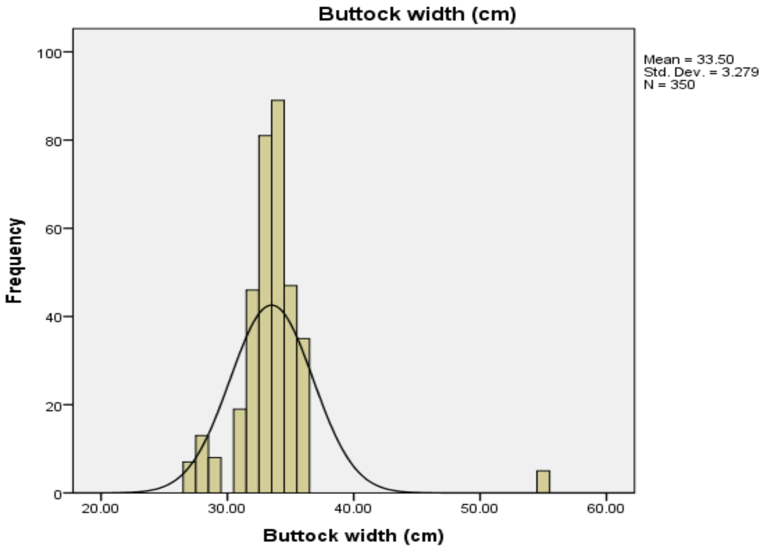

***Figure 6.** Histogram of female participants (BW)*

Loredan et al. (2022) reported that specific differences in body dimensions among groups of different age and gender existed and a high student-furniture mismatch was identified in all educational institutions. Implementation of adjustable school furniture, covering at least two size marks, is needed to provide ergonomic and healthy learning conditions and to further enhance the comfort and well-being of students in the classroom.

In this study, male and female histograms played a crucial role in understanding the distribution of buttock measurements within each gender. These histograms assist in identifying patterns, variations, and potential differences in buttock width and popliteal length between the genders (Figure 1 and Figure 6). This gender-specific data is valuable for ergonomic design, providing insights into how body weight is distributed differently across genders and aiding in the development of products or environments that cater to diverse body shapes and sizes.

Similarly, histograms allow researchers to visually inspect and analyze the distribution of buttock width and popliteal length within each gender. This helps identify common trends, central tendencies, and potential outliers. Understanding the variations in buttock measurements between males and females is also crucial for recognizing any sexual dimorphism. This knowledge aids in tailoring ergonomic designs to accommodate the distinct anatomical differences between men and women.

Accurate anthropometric data forms the foundation of ergonomic design. By analyzing histograms, designers can precisely identify the range and variability of buttock measurements, guiding the development of products or environments that prioritize inclusivity and comfort for all genders. Comparative analysis of male and female histograms facilitates statistical assessments, including mean, median, and standard deviation calculations. These metrics offer a quantitative insight into the distinctions in buttock dimensions between the two genders.

In view of this, the significance of histogram lies in utilizing gender-specific buttock measurements to inform ergonomic design practices, creating products that consider the diversity of body shapes and contribute to improved comfort and functionality.

Table 2 shows the statistical analysis, including metrics such as coefficient of determination (r^2), correlation coefficient (r), Standard Error of Estimate (SEE), and 95% Confidence Intervals which holds significant importance in understanding the relationship between human body weight and the predictors, buttock width, and bottom popliteal length of respondents. The r^2 metric of 0.634 and 0.291 for males and females indicates the proportion of the variability in body weight that can be explained by the model. A higher r^2 defined a better fit of the model to the data (Musa et al., 2022b). Hence, the value of r^2 for male participants (63.4%) remained a better fit of the established model. The correlation coefficient (r), measures the strength and direction of the linear relationship between variables. In this context, it assesses the correlation between body weight, buttock width, and bottom popliteal length (Musa et al., 2022b).

***Table 2**. Regression Analysis of the participants*

Gender	Model			r	r^2	SEE	Sig	95.0% Confidence Interval of B	
	Anthropometric Measurements	B	Std. Error					Lower Bound	Upper Bound
MALE	Constant	12.175	4.069	0.634[a]	0.402	2.671	0.003	4.172	20.178
	Bottom popliteal length (BPL) (cm)	1.021	0.070				0.000	0.884	1.158
	Buttock width (BW) (cm)	0.206	0.106				0.053	-0.003	0.416
FEMALE	Constant	40.327	6.063	0.291[a]	0.084	3.138	0.000	28.402	52.251
	Bottom popliteal length (BPL) (cm)	0.178	0.130				0.170	-0.077	0.433
	Buttock width (BW) (cm)	0.286	0.051				0.000	0.185	0.387
Predictors: Constant, Buttock width (cm), Bottom popliteal length (cm) Dependent Variable: Human Body weight (kg)									

The Standard Error of Estimate, (SEE) quantifies the accuracy of predictions made by the model. A lower SEE indicates a better precision in estimating body weight based on buttock width and bottom popliteal length (Musa et al., 2022a). Table 2 shows a lower SEE of 2.671 and 3.138 for males and females participants respectively. The 95% Confidence Intervals provide a range within which we can be 95% confident that the true value of the parameters, such as coefficients in the model equation, lies. Table 2 offer insights into the precision of our estimates (Musa et al., 2022a; Yeasmin et al., 2022). The male and female regression scatter plots generated from the study were shown in Figure 7 to Figure 10.

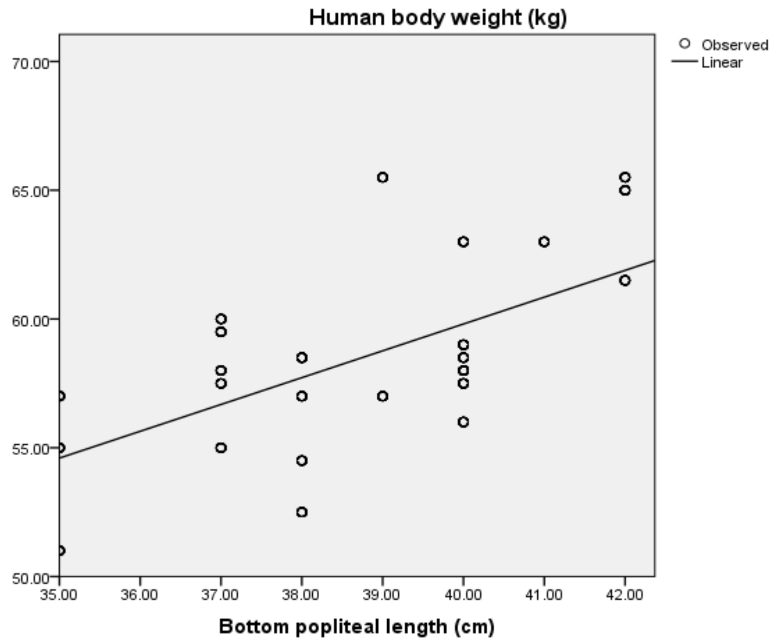

Figure 7. *Female scatter plot for HBW-BPL*

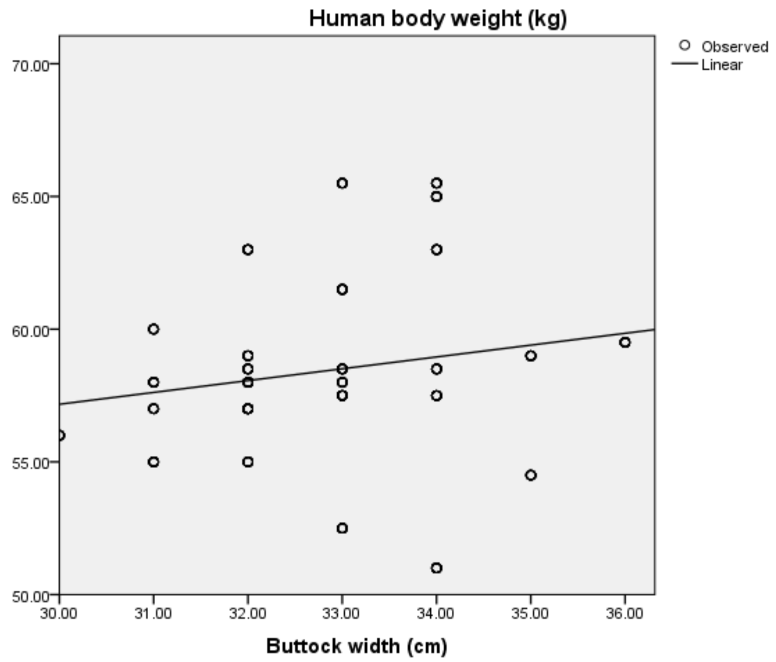

Figure 8. *Male scatter plot for HBW-BW*

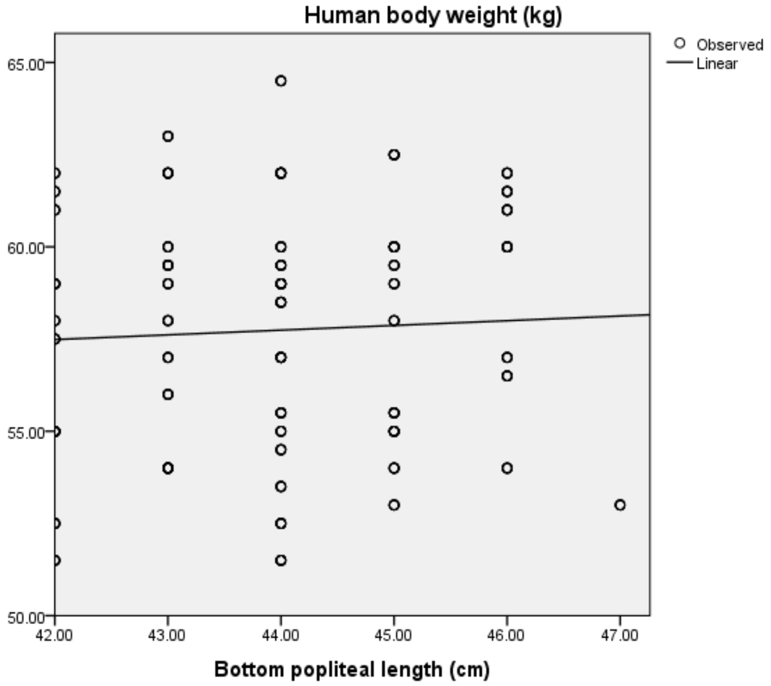

Figure 9. *Female scatter plot for HBW-BPL*

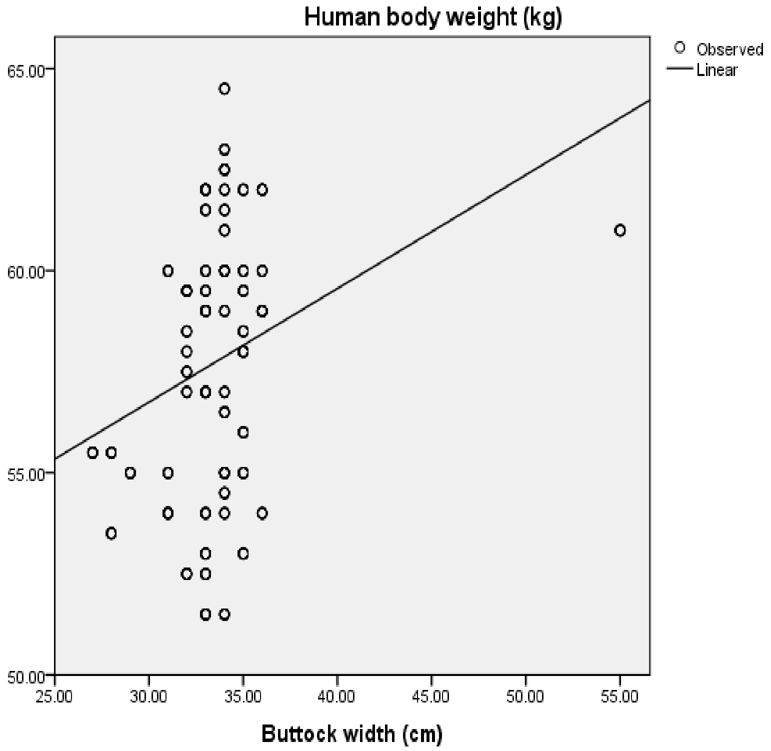

Figure 10. *Female scatter plot for HBW-BW*

This scatter plots serves as crucial tools for understanding the relationship between buttock measurements (width and popliteal length) and human body weight within each gender. This scatter plots assist the author to visually assess the correlation between buttock measurements and human body weight (Figure 3 and Figure 4). Analyzing the regression lines allows for a quantifiable understanding of how changes in buttock dimensions correspond to changes in human body weight.

The regression scatter plots contributes to the precision of ergonomic design by providing designers with specific data points and statistical measures. This information aids in creating products that are not only inclusive but also accurate in estimating human body weight based on buttock dimensions. The scatter plots also serve as a visual representation of the data, helping to validate or refine assumptions made in the study.

Regression scatter plots also help identify any outliers or unusual data points within each gender group. Detecting outliers is crucial for understanding cases where the relationship between buttock measurements and body weight may deviate from the general trend. The regression scatter plots are essential for validating the accuracy of the regression models developed in the study. Researchers can compare the predicted body weight values from the regression equations with the actual body weights, ensuring the reliability and validity of the estimation models.

Human body weight estimation based on buttock measurements have inherent variability. The scatter plots allow the author to observe the spread of data points around the regression line, providing insights into the degree of variability in the relationship and helping designers account for this variability in their ergonomic solutions. Regression scatter plots also highlight potential variations in the relationship between buttock measurements and body weight across different demographics within each gender, such as age groups or ethnicities. This information contributes to designing products that consider diverse demographic characteristics.

In view this submission, male and female regression scatter plots play a pivotal role in quantifying and visualizing the relationship between buttock measurements and human body weight. These tools enhance the precision of ergonomic design and contribute to the development of more accurate estimation models tailored to specific gender differences. In essence, male and female regression scatter plots offer a comprehensive and dynamic view of the relationship between buttock measurements and body weight. They not only aid in immediate design considerations but also provide a foundation for ongoing refinement and adaptation in the field of ergonomic design. Table 3 shows the established model equations.

Table 3. *Model equations*

Gender	Anthropometric Measurement	Model Equations
Male	Human Body weight (HBW)	= 12.175 + 1.021(BPL) + 0.206 (BW)
Female	Human Body weight (HBW)	= 40.327 + 0.178 (BPL) + 0.286 (BW)
Dependent Variable: Human Body weight (kg)		

The established model equations are crucial for predicting body weight based on buttock width and bottom popliteal length (Table 3). They provide a mathematical representation of the relationship uncovered through the analysis (Musa et al., 2023). These statistical measures collectively enhance our understanding of the reliability and validity of the model in estimating body weight from the specified predictors, contributing to the overall robustness of the study findings. Yuan et al. (2020) reported that Buttock-popliteal length, weight, body mass index, body shape and weight distribution, all have important effects on the distribution of body pressure at the human-chair interface.

4. CONCLUSION

This study provides valuable insights into the use of buttock measurements, specifically buttock width and bottom popliteal length, as predictors for estimating body weight. Through thorough statistical analysis and exploration of these anthropometric dimensions, the author has established meaningful correlations with overall body weight. The findings emphasize the practicality of incorporating buttock measurements in diverse fields, including healthcare, ergonomics, and product design. Building upon previous studies hinting at the feasibility of using buttock dimensions for body weight estimation, this research delves into the intricacies of these measurements, offering a comprehensive understanding of their relationships with body weight and enhancing the foundation for accurate and accessible methods of body weight prediction.

The findings suggest integrating buttock width and popliteal length measurements in ergonomic product design, especially for seating arrangements and weight-bearing products. Healthcare practitioners can consider incorporating buttock measurements into health assessments, aiding in more accurate estimations of body weight without the need for direct weight measurements. Manufacturers and designers are encouraged to customize products such as chairs, mattresses, and vehicle seats based on buttock dimensions, ensuring optimal comfort and support for a diverse range of individuals.

The study's significance lies in the innovative link it establishes between furniture design and body weight estimation, a connection not previously explored. Unlike conventional approaches solely focused on furniture design, this research uniquely integrates anthropometric measurements like buttock width and bottom popliteal length. By examining the relationships between these measurements and the distribution of human body weight, as well as body mass index, the study pioneers a comprehensive understanding that extends beyond existing research. This novel approach contributes to ergonomic design by providing a nuanced perspective, ensuring that furniture is tailored not only to anatomical dimensions but also aligned with individual body weight variations. Consequently, this study bridges a crucial gap in the existing literature, offering an original and holistic exploration of the interplay between furniture design and body weight estimation.

The author recommends further research to explore the predictive capabilities of buttock measurements across different demographics and populations. Additionally, longitudinal studies could provide insights into the stability of these correlations over time. Validation of the findings in clinical settings is recommended to ascertain the reliability of buttock measurements for body weight estimation in practical applications, especially in healthcare and rehabilitation contexts.

In conclusion, the study advocates for the integration of buttock measurements as a viable and accessible method for estimating body weight, offering potential benefits in various domains. The recommendations provide practical implementation avenues and suggest future research to enhance the robustness of these predictive relationships.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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