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TECHNOLOGICAL INFORMATION

Finger length as a potential metric for assessing human weight: An ergonomic study

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ABSTRACT. This study investigates the potential link between finger lengths and human weight within the field of ergonomics, aiming to establish finger length as a reliable indicator of human weight. The research involved 215 healthy young male and female participants, selected in Abeokuta South Western Nigeria, using the snowball sampling technique. Employing statistical analyses and regression models, the study explores the nuanced relationship between finger length and human weight. Regression analysis revealed specific finger length L5D ($r = 0.307$), R1D ($r = 0.338$), and R5D ($r = 0.331$) are statistically more reliable for determining human weight, while R2D ($r = 0.066$) and L2D ($r = 0.057$) are less reliable, providing valuable insights for ergonomic applications. Multiple regression analysis reinforced these findings with robust model equations. Single and multivariate regression analyses deepened the study, yielding high correlation coefficients and coefficients of determination. The practical implications of this correlation are highlighted, particularly in shaping ergonomic design principles for products and environments accommodating diverse body types effectively. This research serves as a foundation for future investigations, emphasizing the potential for extending the study to a larger and more diverse population, thereby enriching the understanding of the intricate interplay between finger length and human weight.

Keywords: Ergonomics; Anthropometry; Finger length; Human weight assessment; Body composition.

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Introduction

In the realm of ergonomic studies, researchers have endeavored to identify reliable indicators for evaluating diverse aspects of human physiology. One intriguing avenue of exploration involves investigating the potential correlation between finger length and human weight. This study aims to delve into the hypothesis that finger length could serve as a viable metric for assessing an individual's weight, thereby contributing to a deeper understanding of ergonomic considerations. The study uniquely investigates the correlation between finger length and human weight, with a particular emphasis on the influence of geographical location on this relationship. This research addresses a significant gap in the existing literature by examining an innovative and non-invasive metric for estimating human weight, which is crucial for ergonomic assessments and applications. Previous studies have largely overlooked the potential of finger length as a predictive measure for weight, and none have adequately considered the variability introduced by different geographic regions. This study aims to fill this gap by providing comprehensive data and analysis on how finger length can serve as a reliable indicator of weight, tailored to specific populations and locations.

Ahuja et al. (2018) explored the estimation of stature from finger length, conducting the study among students at Gujarat Forensic Sciences University in India, measuring all ten fingers of each subject. Stature determination was accomplished through linear regression equations. Similarly, Rhiu and Kim (2019) further investigated the relationship between stature and the lengths of fingers and phalanges in the adolescent population, deriving linear models for stature estimation from five fingers and 14 phalanges (Rhiu and Kim, 2019). Various authors (Balachandran, 2017; Raju et al., 2014) have also developed models to determine stature using index (2D) and ring (4D) finger lengths.

Recent studies (Smith et al., 2021; Brown and Jones, 2022) have indicated the significance of finger proportions in relation to body composition, providing a promising avenue for ergonomic research. Anthropometric measurements continue to be pivotal in diverse fields such as product design, workplace optimization, and health assessment (Johnson, 2019; Williams and Miller, 2020). Smith et al. (2021) offer insights into the connection between finger length and body mass index (BMI), suggesting a nuanced relationship and the potential utilization of finger length as a proxy for assessing weight-related parameters. Additionally, Brown and Jones (2022) delve into the genetic underpinnings of finger proportions and their potential role in influencing weight distribution. These studies lay the groundwork for a more comprehensive exploration of the intricate interplay between finger length and human weight.

Several researchers (Musa et al., 2023; 2022a; 2022b; 2022c; Esomonu et al., 2016; Singh et al., 2013; Fogal, et al., 2015), have developed models to determine stature or body height using various anthropometric measurements such as arm span length, leg length, knee height, and foot length .

This current investigation is crucial for acknowledging the multifaceted nature of human ergonomics and the potential implications of a link between finger length and human body weight. The novelty in this study lies in exploring the potential of finger lengths as an alternative to determining human body weight among residents of Abeokuta metropolis. The author discovered a scarcity of literature on the study of human body weight using finger length. This study aims to contribute valuable insights to the evolving landscape of ergonomic research, recognizing that in the dynamic field of ergonomic research, the quest for effective indicators to assess various facets of human physiology remains an ongoing pursuit.

Materials and methods

Sample Acquisition

The research involved the inclusion of two hundred and fifteen (215) healthy young male and female participants, free from any physical disability, selected at random through the snowball sampling technique within Abeokuta, South Western Nigeria. The adoption of the snowball technique was motivated by the prevalent cases of human kidnapping and insecurity in Nigeria. Snowball sampling, while useful for reaching specific populations, has notable limitations, such as selection bias. This bias occurs because the sample may not be representative of the broader population, as participants often refer individuals with similar characteristics or views. Efforts to mitigate bias include diversifying initial contacts and combining snowball sampling with other sampling methods to enhance representativeness.The study's participants ranged in age from 18 to 28 years, and anthropometric data collection occurred between March 2023 and November 2023.

The age range of 18 to 28 years was selected for the participants due to several factors. This demographic often represents a transitional phase from adolescence to adulthood, characterized by significant life changes and decision-making processes. Additionally, individuals within this age group are typically more accessible and responsive to participation in studies, particularly those involving university students or young professionals. This range also captures a critical period for examining behaviors, attitudes, and developmental milestones relevant to the study's objectives.

Anthropometric measurements

In the context of ergonomic workplace and workstation design, anthropometric dimensions are recognized as crucial. The measurements of anthropometric body dimensions adhered to ISO 7250 standards. However, the specific anthropometric measurement method depended on the relevant procedures and equipment designs. Finger lengths (both left and right hand) and body weight were measured using a plastic (0 – 150mm) Electronic LCD digital vernier caliper (Figure 1) and a digital weighing scale (0.1 – 180kg) Electronic scale with LCD (Figure 2). Diagrammatic representation of measuring finger lengths in an infograhic format was shown in Figure 3. Participants were required to be barefoot when using the weighing scale. For finger length measurements, participants were seated in an upright position, and digital vernier calipers were employed for measurement (Figure 4). It's important to note that individuals with missing or amputated fingers were excluded from the study. Figure 4 shows the illustration of the process involved in the measuring of finger lengths.

Figure 1. Plastic Digital Venier Caliper (0 – 150 mm) Electronic LCD.

Figure 2. Digital Weighing Scale (0.1 – 180kg) Electronic Scale with LCD.

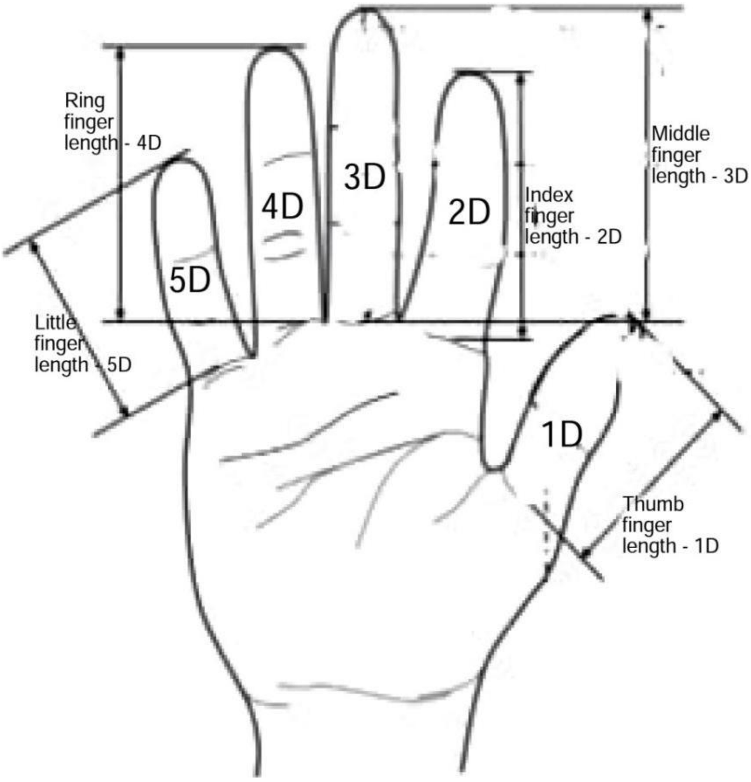

Figure 3. Graphical representation of finger lengths measurement .

Figure 4. Operation of measuring the finger length.

Statistical analysis

The data gathered for this study underwent analytical scrutiny using SPSS software version 21 and Microsoft Excel (2010) equipped with data analysis tools. Calculations encompassed the mean, standard deviation, and the range (minimum and maximum) of finger lengths on both the right and left hand, along with human weight (HW). Additionally, statistical parameters examined in the study involved the correlation coefficient (r), coefficient of determination (r^2), Standard Error of Estimates (S.E.E), and 95% confidence intervals. Single and multivariate regression analyses were employed in this study to formulate model equations for estimating human weight (HW) based on finger measurements.

Regarding the linear regression model equation, the formula utilized to ascertain human weight is presented below:

$$Y = \beta + bx_1 + bx_2 + bx_3 + \ldots\ldots\ldots + bx_n \quad (1)$$

where,

Y = Human weight (kg)
β = Constant (cm)
b = regression coefficient (cm)
x = finger length (cm)

Results and discussion

The outcomes of the descriptive analytical evaluation on the anthropometric data gathered in the study are presented in (Table 1). (Table 2) presents the correlation coefficient and single-variable regression analysis of the study while (Table 3) and (Table 4) shows the correlation coefficient (multivariate) and Regression analysis (multivariate) of the study respectively.

Table 1. Socio-Descriptive Measurement.

Anthropometric Measurement	Mean	Std. Deviation	Minimum	Maximum
Age (years)	22.52	2.24	18.00	28.00
Human weight (HW) (kg)	71.31	15.83	50.20	104.00
Right thumb Finger (R1D) (cm)	6.67	0.65	5.89	8.42
Right Index Finger (R2D) (cm)	7.57	0.69	6.54	9.04
Right Middle Finger (R3D) (cm)	8.53	0.68	7.01	9.90
Right Ring Finger (R4D) (cm)	7.67	0.79	6.27	9.07
Right Little Finger (R5D) (cm)	6.31	0.52	5.44	7.50
Left thumb Finger L1D) (cm	6.76	0.67	5.85	8.46
Left Index Finger (L2D) (cm)	7.45	0.63	6.55	8.84
Left Middle Finger (L3D) (cm)	8.26	0.88	6.83	9.92.
Left Ringer Finger (L4D) (cm)	7.64	0.68	6.59	8.84
Left Little Finger (L5D) (cm)	6.28	0.48	5.35	7.33

Table 2. Correlation coefficient and regression analysis (Single).

Anthropometric Measurement	r	r^2	F	Sig.	β	b	Model Equation
R1D (cm)	0.338	0.115	27.556	.000	15.946	8.305	HW = 15.95 + 8.31(R1D)
R2D (cm)	0.066	0.004	0.937	.334	59.790	1.522	HW = 59.79 + 1.52(R2D)
R3D (cm)	0.247	0.061	13.804	.000	22.448	5.731	HW = 22.45 + 5.73(R3D)
R4D (cm)	0.290	0.008	1.757	.186	57.428	1.810	HW = 57.43 + 1.81(R4D)
R5D (cm)	0.331	0.109	26.144	.000	7.197	10.167	HW = 7.19 + 10.7(R5D)
L1D (cm	0.124	0.015	3.302	.071	51.711	2.900	HW = 51.71 + 2.90(L1D)
L2D (cm)	0.057	0.003	.696	.405	60.615	1.435	HW = 60.61 + 1.44(L2D)
L3D (cm)	0.167	0.028	6.095	.014	46.589	2.994	HW = 46.59 + 2.99(L3D)
L4D (cm)	0.133	0.018	3.814	.052	47.602	3.103	HW = 47.60 + 3.10(L4D)
L5D (cm)	0.307	0.165	42.178	.000	-14.034	13.579	HW = 13.58(L5D) − 14.03

Dependent Variable: Human weight (HW) (kg).

Table 3. Correlation coefficient (multivariate).

Model	r	r^2	Adjusted r^2	Std. Error of the Estimate	Sig.	95.0% Confidence Interval for B	
						Lower Bound	Upper Bound
1	0.338[a]	0.115	0.110	14.93	0.134	-4.938	36.830
					0.000	5.186	11.423
2	0.475[b]	0.226	0.219	13.99	0.000	18.769	61.563
					0.000	14.203	23.827
					0.000	-17.148	-8.127
3	0.554[c]	0.306	0.297	13.28	0.12	-4.504	39.875
					0.00	6.984	17.575
					0.00	-23.344	-13.603
					0.00	10.643	24.735
4	0.407[d]	0.165	0.161	14.49	0.29	-40.009	11.941
					0.00	9.458	17.701
5	0.552[e]	0.305	0.298	13.26	0.34	-35.313	12.225
					0.00	25.612	39.270
					0.00	-20.626	-11.060
6	0.595[f]	0.354	0.344	12.82	0.46	-31.666	14.382
					0.00	28.370	41.835
					0.00	-36.847	-20.948
					0.00	4.896	14.507
7	0.688[g]	0.474	0.464	11.59	0.05	0.299	45.657
					0.00	34.025	46.553
					0.00	-38.170	-23.745
					0.00	16.464	27.638
					0.00	-25.933	-14.449

Table 4. Regression analysis (multivariate).

Model	Anthrop Measure (cm)	B-value	Model equation
1	B	15.946	HW = 15.946 + 8.305(R1D)
	R1D	8.305	
2	B	40.166	HW = 40.166 + 19.015(R1D) − 12.637(R2D)
	R1D	19.015	
	R2D	-12.637	
3	B	17.686	HW = 17.686 + 12.280(R1D) − 18.474(R2D) + 17.689(R5D)
	R1D	12.280	
	R2D	-18.474	
	R5D	17.689	
4	B	-14.034	HW = 13.579(L5D) -14.034
	L5D	13.579	
5	B	-11.544	HW = 32.441(L5D) − 15.843(L4D) − 11.544
	L5D	32.441	
	L4D	-15.843	
6	B	-8.642	HW = 35.102(L5D) - 28.898(L4D) + 9.701(L3D) − 8.642
	L5D	35.102	
	L4D	-28.898	
	L3D	9.701	
7	B	22.978	HW = 22.978 + 40.289(L5D) −30.958(L4D) + 22.051(L3D) − 20.191(L2D)
	L5D	40.289	
	L4D	-30.958	
	L3D	22.051	
	L2D	-20.191	

1 Predictors: (Constant), Right thumb Finger (R1D) (cm). 2 Predictors: (Constant), Right thumb Finger (R1D) (cm), Right Index Finger (R2D) (cm). 3 Predictors: (Constant), Right thumb Finger (R1D) (cm), Right Index Finger (R2D) (cm), Right Little Finger (R5D) (cm). 4 Predictors: (Constant), Left Little Finger (L5D) (cm). 5 Predictors: (Constant), Left Little Finger (L5D) (cm), Left Ringer Finger (L2D) (cm). 6 Predictors: (Constant), Left Little Finger (L5D) (cm), Left Ringer Finger (L2D) (cm), Left Middle Finger (L3D) (cm). 7 Predictors: (Constant), Left Little Finger (L5D) (cm), Left Ringer Finger (L4D) (cm), Left Middle Finger (L3D) (cm), Left Index Finger (L2D) (cm).

Comparisons with other studies are challenging due to the unique focus of this research. While past studies used finger lengths for stature determination, this study exclusively employs them for human weight model equations. Challenges may arise in obtaining finger lengths for lepers or patients with missing fingers, suggesting a potential benefit in incorporating phalanges for more effective human weight determination.

(Table 1) shows the descriptive statistics on the human weight (HW) and the finger length digit (left and right hands) between male and female respondent. The results indicate a range of 50.2kg to 104kg for respondents' HW. The results further revealed the single linear regression analysis (Table 2) with the model equations with respect to finger lengths. (Table 2) reveals that L5D (r = 0.307), R5D (r = 0.331), and R1D (r = 0.338) are statistically more reliable for determining human weight (HW), while R2D (r = 0.066) and L2D (r = 0.057) are less reliable.

The implications of these results are significant for ergonomic assessments and potential applications in health monitoring. The stronger correlations of L5D, R5D, and R1D with HW suggest that these finger lengths could serve as effective, non-invasive predictors for estimating an individual's weight. This finding can be particularly useful in settings where quick and easy weight estimation is necessary, such as in remote health assessments or ergonomic evaluations. Similarly, understanding which finger lengths correlate more strongly with weight can help in the design of ergonomic tools and devices tailored to different body weights, enhancing comfort and efficiency.

However, ability to estimate weight from finger length can aid in identifying individuals who may need further health evaluations or interventions, especially in areas with limited access to traditional weighing scales. The weaker correlations of R2D and L2D indicate that not all finger lengths are equally predictive of weight. This variability highlights the need for further research to understand the underlying anatomical or physiological reasons and to explore whether other body measurements might also serve as reliable weight predictors.

To establish a more robust regression model equation, multiple regression analysis combines finger length variables (Table 3), model equations 3, 5, 6, and 7 (r = 0.554, 0.552, 0.595, and 0.688; r^2 = 0.306, 0.305, 0.354, and 0.474; SEE = 13.28, 13.26, 12.83, and 11.59) emerge as statistically reliable predictors of HW.

In (Table 4), the multivariate model equation combining all finger lengths identifies model equations 3, 5, 6, and 7 as the most reliable for determining HW, with model equation 1 being the least reliable. Beyond scientific inquiry, establishing a link between finger lengths and human weight holds practical implications. This correlation could inform ergonomic design principles for products and environments accommodating diverse body types effectively. Williams and Miller's (2020) exploration of ergonomic applications underscores the broader relevance of anthropometric research in shaping user-centric designs. The study confirms significant correlations between human weight and finger lengths (L5D, R5D, and R1D) in Abeokuta, South Western Nigeria. Notably, there is a lack of literature on this study's estimation of human weight from finger length, highlighting its novelty.

Understanding the correlation between finger length and weight can directly impact ergonomic design in various industries. For instance, office furniture can be designed to better support individuals based on their estimated weight, improving comfort and reducing the risk of injury. In wearable technology, devices can be tailored to fit more comfortably and function more effectively based on body weight estimations derived from finger lengths. Similarly, automotive design can benefit from this research by creating more adaptive seating and control configurations.

Comparisons with other studies are challenging due to the unique focus of this research. While past studies used finger length for stature determination (Hasan et al., 2017; Jindal 2018; Ahuja et al. 2018; Rhiu and Kim 2019; Kilic et al. 2019; Yadav and Shakya 2020; Bakirci and Cay, 2022), this study exclusively employs them for human weight model equations. Challenges may arise in obtaining finger length for lepers or patients with missing fingers, suggesting a potential benefit in incorporating phalanges for more effective human weight determination. To ensure the practical applicability of these findings, it is crucial to validate the model equations in diverse populations and settings. Implementing this knowledge can begin with pilot studies that test the model's accuracy in different demographic groups. Collaborations with industry partners can help integrate these findings into product design processes.

Conclusion

In summary, delving into the potential correlation between finger length and human weight within the realm of ergonomics unveils a promising frontier. While current research offers intriguing insights, further investigations are essential to unravel the intricacies of this relationship. By expanding upon existing knowledge and employing rigorous methodologies, researchers can contribute to a more nuanced comprehension of how finger lengths may serve as a valuable metric in the multifaceted domain of ergonomic design.

This study's sample size and demographic constraints may limit the generalization of the findings. Future studies should include larger and more diverse samples to validate and expand upon these results. Addressing these limitations will strengthen the confidence in using finger lengths as a reliable metric for estimating human weight. The study's findings contribute to ergonomic and anthropometric research, offering novel insights and practical applications that can enhance user-centric design across various industries.

Extending the study to encompass a larger and region-specific population could enhance its scope. It is important to note that the study's limitation lies in its inability to be generalized, as the sample was collected exclusively from Abeokuta, South Western Nigeria. Future research should explore the correlation between finger length and weight in other geographic regions and among different age groups to enhance the model's robustness and generalization. Investigating additional anthropometric predictors of weight can further refine the model equations and their applicability.

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