Ergonomic Assessment of Residential Kitchen Workspaces in Nigeria: A Case Study of Three Local Governments in Oyo State

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Abstract

Residents spend significant hours per day in the kitchen while performing various activities. Considering this as well as potential indiscriminate designs of kitchen workspace in Nigeria, kitchen users may suffer from awkward position, fatigue, and stress. This study aimed to evaluate residential kitchens in three local government areas in Oyo State, Southwest Nigeria, for the potential mismatch between the design of kitchen workspace and the users. One hundred kitchen users (male and female) aged 18 to 70 years were purposefully selected and their respective residential kitchen workspace. Eight kitchen workspace design parameters and five corresponding anthropometric data of the kitchen users were measured using standard procedures. The measurements were compared using relevant ergonomic criteria to determine a match or mismatch (low and high) between the selected kitchen workspace designs and the anthropometric dimensions of users. The assessment results show that the heights of the countertop, burner, microwave, pastry surface, base cabinet, sink, and wall cabinet match 13, 3, 1, 8, 5, 10, and 1% of the kitchen users, respectively. Consequently, the results indicate a significant mismatch between the kitchen workspace design and users' body dimension. The high percentage of mismatches between kitchen workspace designs and the anthropometric data of kitchen users was attributed to the absence of ergonomic considerations in designing the kitchens.

Keywords: Kitchen Workspace Design and Users, Mismatch, Ergonomics Standard, Anthropometry.

1. INTRODUCTION

Food preparation and consumption have occupied a special role in human lives and dwellings since humanity's dawn (Wu & Chen, 2014; Alt *et al*., 2022). According to Abraham Maslow, food is one of the biological and basic requirements for human survival (Mcleod, 2023). Therefore, space for food preparation and production is a significant part of individual homes. The kitchen workspace can be described as part of a building designed and equipped to prepare different types of food to feed the households (Atamewan & Otu, 2018). Also, other chores, such as washing, arranging, and sorting are performed in the kitchen. Thus, the comfort of a kitchen is essential considering the frequency of use and various operations being carried out in it (Maguire *et al*., 2014; Shete *et al*., 2015; Ismail *et al*., 2020). So, it is important that at the design and construction stages of buildings, the design of their workspace and layout should consider the necessary physical characteristics of the potential kitchen users (Ismail *et al*., 2020; Ismail *et al*., 2021). This includes reference to the user's height, arm reach, and other aspects. Such design

consideration meets the user's specific needs, aids comfortability and productivity when performing kitchen tasks (Patil & Rajhans, 2018).

Kitchen operations involve repetitive tasks such as chopping and washing (Shete *et al.*, 2015). Some of these operations may involve unnatural body postures in the kitchen workspace and may be awkward for the users. For example, some operations require that users hold their heads down to cook food, bend when arranging appliances, stretch to reach platforms or higher cabinets, and lift, which poses a serious risk to kitchen users' neck region and the thoracic part (Adeyemi *et al*, 2014; Vorosne Leitner *et al*., 2018; Ismail *et al*., 2020). However, this can be mitigated if proper ergonomic principles are considered. According to Kolawole *et al.* (2019), health risks can be eased when anthropometric data are factored into the design. That is, by considering the anthropometric dimensions of kitchen users in designing kitchen workspace, usability is improved, a sense of comfort is enhanced, and the risk of musculoskeletal disorders associated with kitchen operations is greatly reduced.

In Nigeria, kitchen workspace designs have been mostly done with little reference to the anthropometric data of Nigerian users. Many of the equipment in the kitchen are either imported or developed locally without much consideration for the anthropometric data of Nigerian users. Hence, many users who spend quite a lot of time preparing food are at potential risk of fatigue and stress. Such stresses may include back pain and tendinitis, which are felt most acutely in the lower and upper back regions (Moch, 2013). This has led to an increase in musculoskeletal disorders (MSDs) among women who spend significant time working in the kitchen (Bhatia & Singla, 2019; Sharma *et al.*, 2019; Park *et al.*, 2021).

Despite the existing concerns about posture and ergonomic problems in the kitchen, it is still being used that way, which of course poses a lot of threats to users. The current study is therefore important as it pays attention to the ergonomic issues in users' interactions with their kitchen. Also, knowledge is scarce, particularly in Nigeria, about the ergonomic suitability of kitchen workspace designs for various kitchen operations, resulting in many mismatches between the kitchen user's anthropometric dimensions and their respective kitchen workspace design. Therefore, this study aims to ergonomically assess residential kitchens for a potential mismatch between selected kitchen workspace design parameters and anthropometric dimensions of the users in Akinyele, Ibadan North, and Ibadan Southwest local government area of Oyo State, Nigeria.

2. METHOD

2.1 Sample and Study Design

A questionnaire targeted at kitchen users in the three local government areas was developed using relevant kitchen workspace design parameters, and anthropometric data of kitchen users that were identified through a systematic literature review. The questionnaire targeted 100 participants from individual homes within the study area with ages ranging between 18 and 70 years. The age range used was perceived as active users' age range, while the minimum age (i.e. 18 years) is considered the age when stature no longer increases for most people. The designed questionnaire includes questions related to kitchen designs and the anthropometric data of the users. A total of one hundred kitchens were considered, and the relevant kitchen workspace design parameters and anthropometric data of the users were collected. Matching criteria equations were formulated and applied to assess the potential mismatch of kitchen design parameters against its users.

2.2 Kitchen Workspace Design Parameters

The following kitchen dimensions were considered and measured accordingly using measuring tape that was calibrated in centimeters. These kitchen dimensions are indicated in Figure 1 and described as follows.

1. Sink height from the ground (SHG): This is the vertical distance between the floor and the highest point on the edge of the sink.

2. Burner height (B): This is the vertical distance between the floor and the highest point on the surface of the burner.

3. Microwave Height (M): This is the vertical distance between the edges of a microwave.

4. Microwave height from the ground (MG): This is the vertical distance between the floor and the base of the microwave.

5. Wall Cabinet height (WC): This is the vertical distance between the floor and the highest point on the surface of the cabinet.

6. Base Cabinet height (BC): This is the vertical distance between the floor and the base surface of the wall cabinet.

7. Countertop/Island height (C): This is the vertical distance between the floor and the surface of the countertop.

8. Pastry Surface height (P): This is the vertical distance between the floor and the surface of the pastry surface.

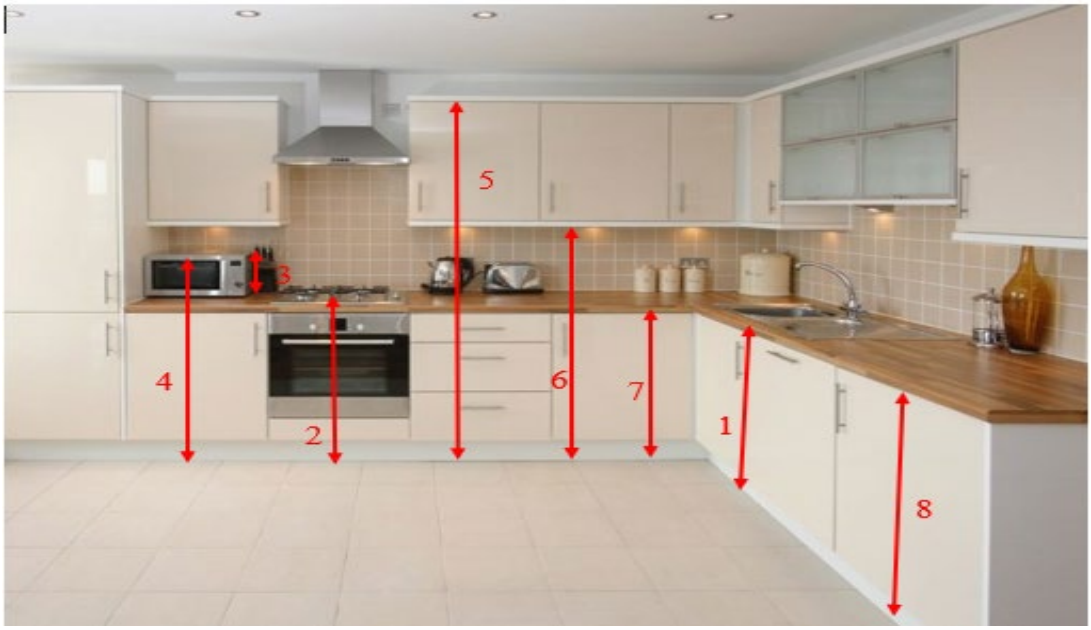


FIGURE 1: Representation of the kitchen design parameters. Source: (Contracting, 2020).

2.3 Anthropometric Data of Kitchen Users

The relevant body parameters of the kitchen users that correspond to the identified kitchen workspace design parameters are indicated in Figure 2 and described as follows (Parcells *et al*., 1999; Castellucci *et al*., 2014; Samuel *et al*., 2016; Anacleto Filho *et al*., 2023):

1. Stature (S): The vertical distance between the floor and the top of the head. This was measured with the subject being erect and looking straight ahead.

2. Eye height (E): It is the vertical distance from the floor to the later (outer) corner of the eye (ectocanthus).

3. Shoulder height (SH): It is measured as the vertical distance from the floor to the acromion (i.e. the bony tip of the shoulder).

4. Elbow height (EH): Measured as the vertical distance from the floor to the depression formed at the elbow where the forearm meets the upper arm.

5. Vertical grip reach (VG): Measured from the floor to the top of a bar grasped in the right hand while the subject stands erect, and the hand within which the bar is grasped is raised as high as it can be conveniently without experiencing discomfort or strain.

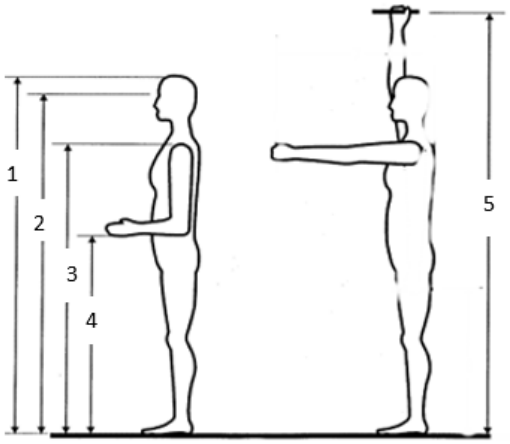


FIGURE 2: Representation of the anthropometric measures. Source: (Khoshabi *et al*., 2020).

2.4 Method for Ergonomic Assessment of Residential Kitchen Workspace

The residential kitchen workspace in this study was assessed by determining a match/mismatch between selected kitchen workspace design parameters and kitchen users. In this study, a match is a fit between the kitchen workspace design parameters and the corresponding anthropometric data of its users, while a mismatch indicates otherwise based on relevant ergonomic principles.

For this purpose, relevant match equations were adopted from relevant American/British ergonomic standards for designing kitchen workspaces since an ergonomic standard for Nigerian kitchen designs had not been fully published at the time of this research. These match equations formed the criteria for comparing design parameters in residential kitchen workspaces against the respective anthropometric data of kitchen users. The match criteria equations for designing the kitchen workspace are described for each parameter as follows.

1. **Countertop Height (C)**

   The countertop is one of the most essential surfaces in the kitchen. Therefore, its height is an important characteristic to consider in the ergonomic design of the kitchen workspaces. C needs to be adapted relatively to elbow height, allowing the hands to be flexed such that the elbow at 90 degrees is between 7 to 10.2 centimeters above the countertop (Regattaexports, 2019; Clair, 2021).

   The match criterion employed to investigate the potential mismatch of C against EH is presented in equation 1.

$$7 \leq (EH - C) \leq 10.2 \quad (1)$$

   Where C is the countertop height, EH is the elbow height.

2. **Burner Height (B)**
Burner height is to be adapted relatively to elbow height, with allowance for hands to be flexed such that the elbow at 90 degrees is between 15 to 18 centimeters above the top of the burner (Regattaexports, 2019; Clair, 2021).

The match criterion employed to investigate the potential mismatch of burner height (B) against elbow height (EH) is presented in equation 2.

$$15 \leq (EH - B) \leq 18 \quad (2)$$

Where B is the burner height, EH is the elbow height.

3. **Sink Height (SHG)**
The sink may be placed at the same level as the countertop. Thus, SHG has to be adapted relatively to elbow height, allowing hands to be flexed such that the elbow at 90 degrees is between 7 to 10.2 centimeters above the countertop.

The match criterion employed to investigate the potential mismatch of SHG against EH is presented in equation 3.

$$7 \leq (EH - SHG) \leq 10.2 \quad (3)$$

Where SHG is the sink height, EH is the elbow height.

4. **Microwave Height from the Ground (MG)**
MG needs to be adapted relatively to shoulder height, allowing the hands to be flexed such that the bottom of the microwave should be between 7 and 8 centimeters below the user's shoulder. The match criterion that was employed to investigate the potential mismatch of MG against SH is presented in equation 4.

$$7 \leq (SH - MG) \leq 8 \quad (4)$$

Where MG is microwave height from the ground, SH is the shoulder height.

5. **Pastry Surface Height (P)**
On this surface, kneading and rolling of dough for baking is done. P needs to be adapted relatively to elbow height, allowing the hands to be flexed such that the elbow at 90 degrees is between 20 and 21 centimeters above the pastry surface (Regattaexports, 2019). The match criterion employed to investigate the potential match/mismatch of P against EH is presented in equation 5.

$$20 \leq (EH - P) \leq 21 \quad (5)$$

Where P is the pastry surface height, EH is the elbow height.

6. **Wall Cabinet Height (WC)**
WC needs to be adapted relatively to countertop height, which is relative to elbow height, allowing the hands to be flexed such that the wall cabinet base is between 45 and 46 centimeters above the countertop. The distance between the wall cabinet's stature and base should be between 30 and 32 centimeters. Also, the shoulder should be at the same level as the base of the wall cabinet. The user's maximum reach should be between 65 and 67 centimeters above the shoulder (Interiorera, 2017; Kitcheneer, 2019).

The match criteria employed to investigate the potential mismatch of WC are presented in equations 6-8.

$$45 \leq (WC - C) \leq 46 \quad (6)$$

$$31 \leq (S - WC) \leq 32 \quad (7)$$

$$65 \leq (VG - SH) \leq 67 \quad (8)$$

Where WC is the vertical distance between the floor and the base surface of the wall cabinet, C is the countertop height, VG vertical grip reach, and SH is the shoulder height.

7. **Base Cabinet Height (BC)**
   BC needs to be adapted relatively to elbow height, allowing the hands to be flexed such that the elbow at 90 degrees is between 7 to 10.2 centimeters above the countertop. The match criterion employed to investigate the potential match/mismatch of BC in this study is shown in equation 9.

$$7 \leq (EH - BC) \leq 10.2 \quad (9)$$

Where BC is the countertop height, EH is the elbow height.

2.5 Data Analysis

Data were collected through oral interviews, direct observation, measurements of body parameters of kitchen users, measurement of selected kitchen workspace design parameters, and structured questionnaires. The collected data were analysed and presented using descriptive statistical techniques with Microsoft Excel software.

3. RESULTS AND DISCUSSION

The results of the ergonomic assessment of residential kitchen workspaces are presented in Figures 3(a-i) in terms of the percentages of high mismatch, match, and low mismatch. The high mismatch in the figures indicates that the minimum limit of the match equation is higher than the corresponding anthropometric of the kitchen user. A match is when the corresponding anthropometric of the kitchen user is within the limits of the match equation, and a low mismatch is when the maximum limit of the match equations is lower than the anthropometric data of kitchen users.

In Figure 3a, the match between the countertop height and the elbow height of the respective kitchen users is 69%, 13%, and 18% for high mismatch, match, and low mismatch, respectively. This result indicates a large percentage of high mismatches between the kitchen users and countertop height in many kitchen workspaces. These mismatches could have led to awkward postures in kitchen users and back and shoulder pains. For the match, only thirteen percent of kitchen users have their elbow height (EH) match the countertop height of their kitchen workspaces.

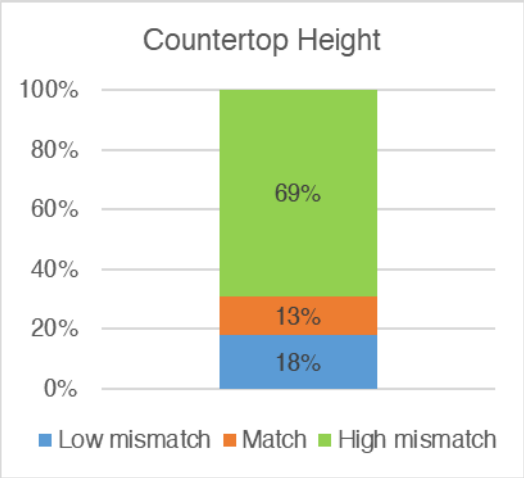
The assessment of the burner height shows 46%, 3%, and 51% for high mismatch, match, and low mismatch, respectively, as shown in Figure 3b. This indicates that a more significant percentage of kitchen users have their elbow height as either high mismatch or low mismatch to the burner height in their kitchen. This implies that most kitchen users would have their elbows flexed restricted during cooking operations and might be at risk of fire burns at the elbow.

Also, the assessment of microwave height and shoulder height of the kitchen users (see Figure 3c – 3f) shows a high level of mismatch (96%). This is the same for the pastry surface height (68%), base cabinet height (92%), and sink height (75%). Thus, most kitchen users would have to bend and lower their heads than necessary whenever they perform operations that require microwaves, sinks, and pastry surfaces.

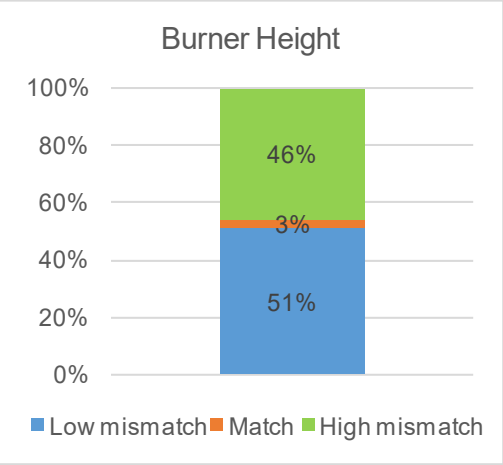
The ergonomic assessment of the wall cabinet indicated a low match of 74% with the stature of kitchen users and a match of 1%, as shown in Figure 3g. Regarding the shoulder height and the vertical grip reach of the kitchen with the wall cabinet, Figure 3h indicates a high mismatch of

76% and an equal match and low mismatch of 12%. Similarly, an ergonomic assessment of the wall cabinet and the countertop, as presented in Figure 3i, shows a significant high mismatch.

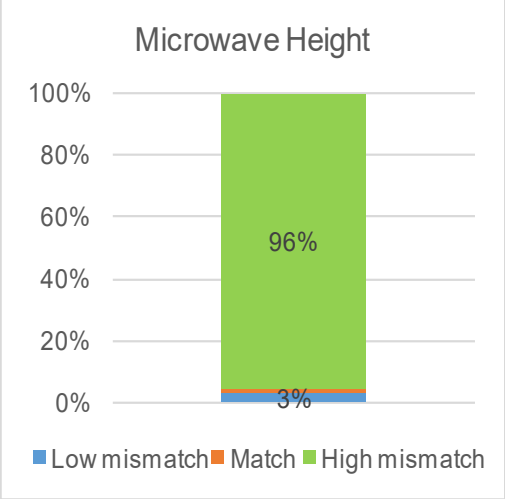
Given the high level of mismatch in the kitchen design parameters and low priority generally assigned to the comfort and functional needs of kitchen users in kitchen design, it would not be surprising if kitchen designs in other local governments, other states, and Nigeria as a whole show a similar level of mismatch between kitchen workspace design and kitchen user.



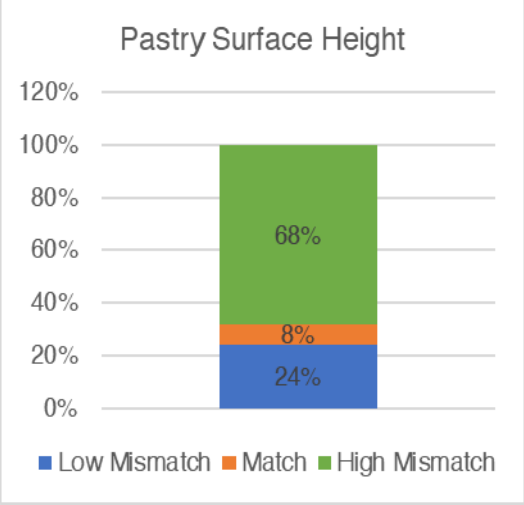
(3a) Match/Mismatch between countertop height and elbow height



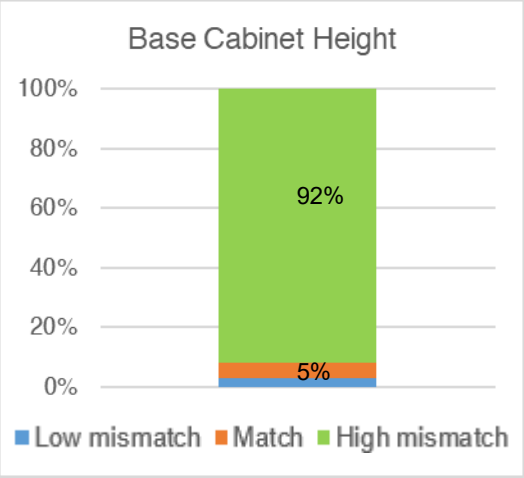
(3b) Match/Mismatch between elbow height and burner height



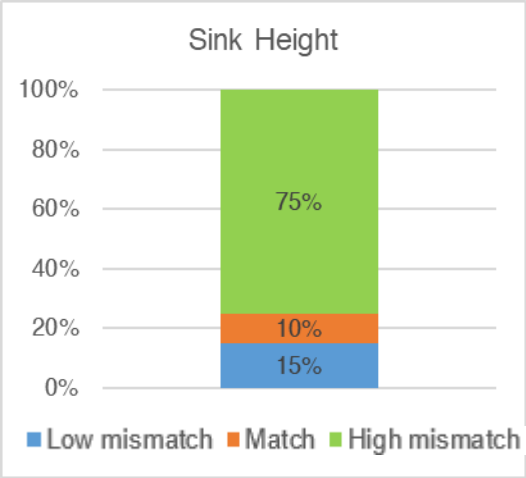
(3c) Match/Mismatch between shoulder height and microwave height



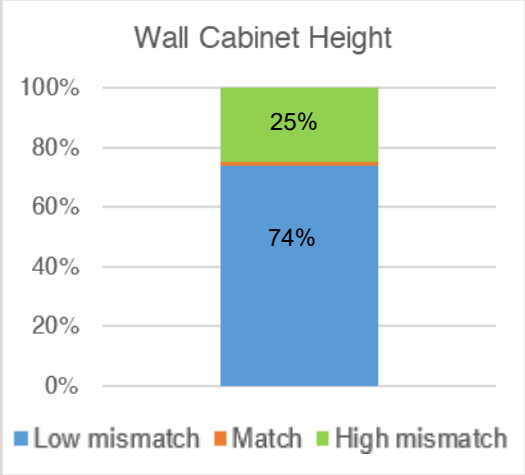
(3d) Match/Mismatch between elbow height and pastry surface height



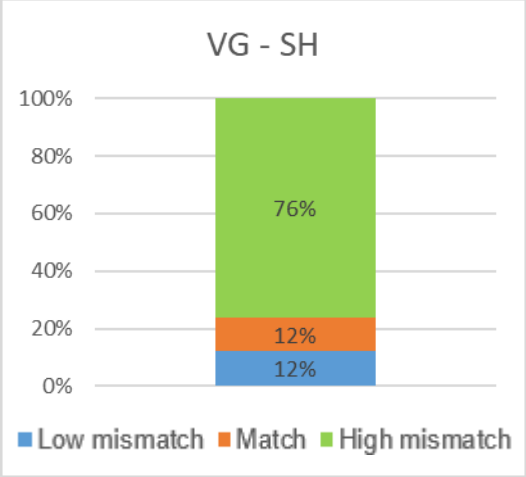
(3e) Match/Mismatch between elbow height and base cabinet height



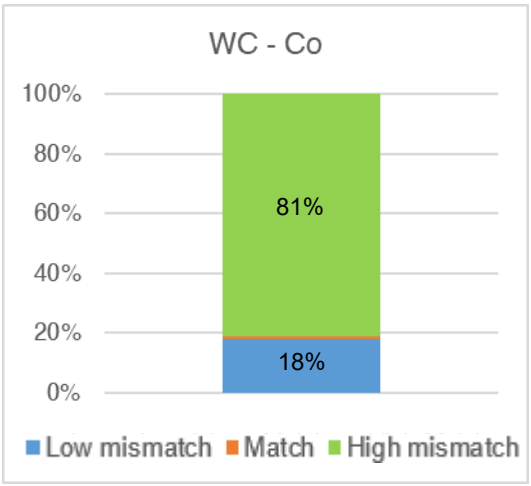
(3f) Match/Mismatch between elbow height and sink height



(3g) Match/Mismatch between stature and wall cabinet height



(3h) Match/Mismatch between shoulder height and vertical grip reach



(3i) Match/Mismatch between wall cabinet and countertop height

FIGURE 3a-i: Percentages of match/mismatch of kitchen users.

The collected kitchen workspace design parameters and anthropometric data of the users were further analysed, and the results are presented in Tables 1 and 2 respectively. Table 1 presents the analysis of kitchen workspace design in terms of mean, standard deviation, minimum, maximum, and percentile (5^{th}, 50^{th}, 90^{th}, 95^{th}, 99^{th}) in centimeters. For sink height (SHG), burner height (B), wall cabinet height (WC), microwave height from the ground (MG), base cabinet height (BC), pastry surface height (P), and countertop height (C), the mean were 92.06, 88.45, 211.75, 110.56, 83.48, 92.70, and 92.70, respectively. The standard deviations (in centimeters) were 6.12, 20.88, 16.26, 12.16, 7.09, 7.94, and 7.94, respectively. The data presented indicates substantial variability in the measured kitchen workspaces, as evidenced by the high deviation from the mean.

		SHG	B	WC	MG	BC	P	C
Mean		92.06	88.45	211.75	110.56	83.48	92.70	92.70
Std. Deviation		6.12	20.88	16.26	12.16	7.09	7.94	7.94
Minimum		75.0	37.0	152.0	89.0	67.0	69.0	69.0
Maximum		107.0	127.0	263.0	145.0	105.0	107.0	107.0
Percentiles	5	81.05	40.05	187.15	91.55	71.00	77.05	77.05
	50	92.00	91.75	212.50	110.00	84.00	93.00	93.00
	90	100.00	110.00	229.00	125.90	91.00	102.00	102.00
	95	100.98	116.00	230.00	131.10	93.00	104.95	104.95
	99	107.00	126.95	.	.	105.00	107.00	107.00

TABLE 1: Analysis of kitchen workspace design parameters.

Table 2 shows the descriptive statistics of the five anthropometric dimensions of the kitchen users (56 females and 44 males). The average mean of stature (S), elbow height (EH), eye height (E), shoulder height (SH), and vertical grip reach (VG) were 170.99, 108.00, 159.04, 143.16, and 216.27 respectively.

		S	EH	E	SH	VG
Mean		170.99	107.995	159.04	143.16	216.27
Std. Deviation		11.09	7.08	11.25	10.33	15.39
Minimum		153	94.0	141	127	185
Maximum		228	130.0	213	199	270
Percentiles	5	156.00	98.00	143.00	129.00	192.00
	50	170.00	109.00	158.00	142.00	217.00
	90	183.00	117.90	170.90	153.90	235.90
	95	187.90	120.00	175.95	159.85	240.00
	99	227.74	129.94	212.81	198.71	269.82

TABLE 2: Analysis of the anthropometrics of kitchen users.

4. CONCLUSION

This study assessed the potential mismatch between kitchen workspace design and kitchen users. Data related to the kitchen workspace design and relevant anthropometric data of kitchen users were collected in three local governments in Oyo state, Nigeria. The collected data were then analysed based on relevant match criteria, and the results were presented. The research findings show an extremely high mismatch between the kitchen workspace design and the anthropometric data of the kitchen users. For example, most kitchen design dimensions are either high mismatched or low mismatched. This implies that anthropometric data of users have not been well considered in the designs of many residential kitchen workspaces in the three local government areas of Oyo State. Thus, it can result in back pain, shoulder pain, easy fatigue, and other musculoskeletal disorders (MSDs) for kitchen users.

The results of this study highlight the fact that the design of kitchens in Nigeria is constructed or acquired without ergonomics consideration, which will, most likely, result in its inadequacy. Therefore, it is recommended that kitchens should be tailored to suit the specific needs and characteristics of the individuals who utilise them. This includes taking into account the anthropometric measurements of kitchen users when designing the workspace.

5. REFERENCES

Adeyemi, H. O., Adejuyigbe, S. B., Akanbi, O. G., Ismaila, S. O. & Adekoya A. F. (2014). Decree of Safe Postures in Manual Lifting Tasks among Some Groups of Construction Workers in Southwestern Nigeria. *International Journal of Ergonomics*, *4*(2), 24–32.

Alt, K. W., Al-Ahmad, A. & Woelber, J. P. (2022). Nutrition and Health in Human Evolution–Past to Present. *Nutrients*, *14*(17), 1–34. https://doi.org/10.3390/nu14173594

Anacleto Filho, P. C., da Silva, L., Mattos, D., Pombeiro, A., Castellucci, H. I., Colim, A., Carneiro, P., & Arezes, P. (2023). Establishing an anthropometric database: A case for the Portuguese working population. *International Journal of Industrial Ergonomics*, *97*(May), 103473. https://doi.org/10.1016/j.ergon.2023.103473

Atamewan, E. E. & Otu, E. E. (2018). Traditional Kitchen Design for Sustainable Low-Income Dwellings in Developing Countries. *Journal of Sustainable Development*, *11*(6), 59. https://doi.org/10.5539/jsd.v11n6p59

Bhatia, A., & Singla, S. (2019). Ergonomic evaluation and customized design of kitchen. *International Journal of Innovative Technology and Exploring Engineering*, *8*(9 Special Issue), 1033–1039. https://doi.org/10.35940/ijitee.I1166.0789S19

Castellucci, I., Arezes, P., & Molenbroek, J. (2014). Applied Anthropometrics in School Furniture Design: Which Criteria Should be Used for Standardization? *Advances in Ergonomics In Design, Usability & Special Populations: Part I*, *18*(April 2015). https://doi.org/10.54941/ahfe100791

Clair, R. (2021). *Standard height not best for kitchen countertops*. https://www.sun-sentinel.com/1986/08/01/standard-height-not-best-for-kitchen-countertops/

Contracting, F. (2020). *L-Shaped Kitchen*. https://fineline-contracting.com/products/kitchen/l-shaped-kitchen/

Interiorera. (2017). *Interior Era*. https://interiorera.in/

Ismail, F. H., Osman, S., & Rahman, F. B. A. (2020). Ergonomics Kitchen: A Better Place to Work. *International Journal of Academic Research in Business and Social Sciences*, *11*(13), 43–53. https://doi.org/10.6007/ijarbss/v11-i13/8501

Ismail, F., Osman, S., & Bte A. Rahman, F. B. (2021). Ergonomics Kitchen: A Better Place to Work. *Journal of Business and Social Sciences*, *11*, 2222–6990. https://doi.org/10.6007/IJARBSS/v11-i13/8501

Khoshabi, P., Nejati, E., Ahmadi, S. F., Chegini, A., Makui, A., & Ghousi, R. (2020). Developing a multi-criteria decision making approach to compare types of classroom furniture considering mismatches for anthropometric measures of university students. *PLoS ONE*, *15*(9 September), 1–25. https://doi.org/10.1371/journal.pone.0239297

Kitchenseer. (2019). *How High Should Kitchen Wall Cabinets Be From The Floor? - Kitchen Seer*. https://kitchenseer.com/how-high-kitchen-wall-cabinets-from-floor/

Kolawole, A., Ikubanni, P., Adeleke, A., Agboola, O., & Alebiosu, A. (2019). Comparative analysis of anthropometric data of Hausas in northern and southern Nigeria. *Journal of Applied Engineering Science*, *17*(2), 168–174. https://doi.org/10.5937/jaes17-20376

Maguire, M., Peace, S., Nicolle, C., Marshall, R., Sims, R., Percival, J., & Lawton, C. (2014). Kitchen living in later life: Exploring ergonomic problems, coping strategies and design solutions. *International Journal of Design*, *8*(1), 73–91.

Mcleod, S. (2023). *Maslow's Hierarchy Of Needs*. https://www.simplypsychology.org/maslow.html#:~:text=1.,thing that motivates our behavior.

Moch, B. N. (2013). Designing an Ergonomics-Based Public Wudu Place for Indonesian Population Using Posture Evaluation Index and Virtual Environment Method. *International Journal of Ergonomics (IJEG)*, *3*(3), 15–24.

Parcells, C., Stommel, M., & Hubbard, R. P. (1999). Mismatch of classroom furniture and student body dimensions: Empirical findings and health implications. *Journal of Adolescent Health*, *24*(4), 265–273. https://doi.org/10.1016/S1054-139X(98)00113-X

Park, S., Lee, J., & Lee, J. H. (2021). Insufficient Rest Breaks at Workplace and Musculoskeletal Disorders Among Korean Kitchen Workers. *Safety and Health at Work*, *12*(2), 225–229. https://doi.org/10.1016/j.shaw.2021.01.012

Patil, A. S., & Rajhans, N. R. (2018). *Human Factors in Designing Workspace: Customizing Kitchen Counter Design*. 286–294. https://doi.org/10.1007/978-3-319-60828-0_29

Regattaexports. (2019). *Kitchen ergonomic justifying 36-inches of your kitchen countertop height*. https://www.regattaexports.com/kitchen-ergonomic-justifying-36-inches-of-your-kitchen-countertop-height/

Samuel, T. M., Aremu, O. O., Salami, I. O., Adetifa, B. O., Onu, L. I., Adegbite, S. E., & Olokose, A. A. (2016). Anthropometric data variation within gari-frying population. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, *8-10 March*, 2712.

Sharma, S., Shaikh, F., Bhovad, P., Kale, J., Gupta, Y., & Bhuta, M. (2019). Risk of musculoskeletal disorders associated with kitchen platform tasks in young and middle-aged women of a metropolitan city: An observational cross-sectional study. *The Indian Journal of Occupational Therapy*, *51*(4), 130–135. https://doi.org/10.4103/ijoth.ijoth_33_19

Shete, K., Pandve, T. H., & Puntambekar, T. (2015). Role of Ergonomics in Kitchen Related Back Problems. *Journal of Ergonomics*, *05*(03), 2014. https://doi.org/10.4172/2165-7556.1000e141

Vorosne Leitner, A., Kajtar, L., & Nyers, J. (2018). Indoor environmental assessment method in residential kitchen. *Thermal Science*, *24*(January), 2055–2065. https://doi.org/10.2298/TSCI180527318V

Wu, J., & Chen, X. (2014). Brief analysis of kitchen design based on the history of western society. *Applied Mechanics and Materials*, *641–642*, 1109–1112. https://doi.org/10.4028/www.scientific.net/AMM.641-642.1109