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Furniture Mismatch Assessment and Human Factor Issues in Primary Healthcare Facilities of Calabar Metropolis, Nigeria

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Abstract

Introduction: Furniture-user mismatch is a recognised occupational health risk, yet no study has systematically evaluated ergonomic compatibility between healthcare workers (HCWs) and furniture in Nigerian primary healthcare facilities (PHCFs). This study assessed the anthropometric profile of HCWs in public PHCFs in Calabar Metropolis, Cross River State, Nigeria, and evaluated the degree of mismatch between their body dimensions and their workstations. **Methods:** A total of 145 HCWs (47 males, 98 females) were recruited across 25 selected PHCFs. Thirteen anthropometric parameters were measured in accordance with ISO 7250. Six chair types (four armchairs and two armless chairs) and fifteen table types were dimensionally assessed. Match and mismatch percentages were computed by comparing furniture dimensions against ergonomically derived acceptable ranges based on the 5th and 95th percentile values of relevant anthropometric parameters. **Results:** Study revealed pervasive mismatch across all furniture types and dimensions. Among armchairs, seat height match rates did not exceed 33.3% in any group, while armrest height match was below 15% across all four types. Armless chairs performed comparatively better, with Chair Type 3 achieving up to 66.7% seat height match in males. Table height mismatch exceeded 70% for nearly all fifteen table types, with upper mismatch being the dominant pattern. **Conclusion:** Findings of the present study demonstrate a critical ergonomic deficit in primary healthcare furniture in Calabar Metropolis and underscore the urgent need for anthropometrically informed furniture design and procurement policies to protect HCWs from musculoskeletal disorder (MSDs) risk.

Keywords: Anthropometry, Ergonomics Mismatch, Healthcare Workers Furniture, Primary Facilities, Musculoskeletal disorders.

Resumen

Introducción: La falta de coincidencia entre muebles y usuarios es un riesgo para la salud ocupacional reconocido, sin embargo, ningún estudio ha evaluado sistemáticamente la compatibilidad ergonómica entre los trabajadores de la salud (TS) y los muebles en los centros de atención primaria de salud (PHCF) de Nigeria. Este estudio evaluó el perfil antropométrico de los trabajadores sanitarios en centros de atención primaria de salud públicos en Calabar Metropolis, estado de Cross River, Nigeria, y evaluó el grado de discrepancia entre las dimensiones de su cuerpo y sus estaciones de trabajo. **Métodos:** Se reclutó a un total de 145 trabajadores sanitarios (47 hombres, 98 mujeres) en 25 PHCF seleccionados. Se midieron trece parámetros antropométricos de acuerdo con la norma ISO 7250. Se evaluaron dimensionalmente seis tipos de sillas (cuatro sillones y dos sillas sin brazos) y quince tipos de mesas. Los porcentajes de coincidencia y discrepancia se calcularon comparando las dimensiones de los muebles con rangos aceptables derivados ergonómicamente basados en los valores de los percentiles 5 y 95 de parámetros antropométricos relevantes. **Resultados:** Stusy reveló un desajuste generalizado en todos los tipos y dimensiones de muebles. Entre los sillones, las tasas de coincidencia de altura del asiento no superaron el 33,3% en ningún grupo, mientras que la coincidencia de altura de los reposabrazos fue inferior al 15% en los cuatro tipos. Las sillas sin brazos tuvieron un rendimiento comparativamente mejor, y la silla tipo 3 logró hasta un 66,7 % de coincidencia en la altura del asiento en los hombres. La discrepancia en la altura de las mesas superó el 70 % en casi los quince tipos de mesas, siendo la discrepancia superior el patrón dominante. **Conclusión:** Los hallazgos del presente estudio demuestran un déficit ergonómico crítico en el mobiliario de atención primaria de salud en Calabar Metropolis y subrayan la necesidad urgente de políticas de adquisición y

diseño de muebles informadas antropométricamente para proteger a los trabajadores sanitarios del riesgo de trastornos musculoesqueléticos (TME).

Palabras Clave: Antropometría, Desajuste Ergonómico, Mobiliario para Trabajadores de la Salud, Instalaciones Primarias, Trastornos Musculoesqueléticos.

Introducción

Primary healthcare facilities (PHFs) or centres (PHCs) serve as the first point of contact for individuals seeking medical assistance and are the foundation of healthcare delivery systems worldwide (World Health Organization, 2017; Paula et al., 2016; Bitton et al., 2017; Kruk et al., 2010). They just not focus on treating illnesses but also serve as an educational platform for communities on health risks and healthy lifestyles thereby preventing diseases and promoting overall wellness (Haque et al., 2020). PHCs operates on principles of accessibility, affordability and community involvement, ensuring that healthcare is available to all segments of society, especially in rural and underserved areas. This makes primary healthcare indispensable particularly in low- and middle-income countries (LMICs) where resources are constrained and health disparities are most pronounced (Bitton et al. 2017; Kruk et al., 2010). In developed countries, Primary healthcare covers about 80% of an individual's lifetime health needs (WHO, 2017; Paula et al., 2016). However, developing countries including Nigeria continues to face challenges such as poor staffing, poor infrastructure and lack of essential basic amenities (Yisa et al., 2025). The ratio of patients per general practice (GP) even with the decreasing workforce in many climes is nothing compared to the Nigerian situation. Living health workers within the country with more working hours (Oche and Adamu, 2013; Yisa et al., 2025). The system has a long history of underfunding and underperformance. Out of the 30,000 PHFs within the country, only about 20% are fully functional (Yisa et al., 2025). To effectively execute their duties requires heavy reliance on furniture items.

Among the many challenges facing PHFs is infrastructural deficits (Kruk et al., 2010; Haque et al., 2020). From an ergonomic standpoint, health workers endure poor working conditions, second only to low honorarium (Odebiyi and Okafor, 2023; Kamijantono et al., 2024). According to Adiga (2023), adequate work-support facilities contribute largely to working conditions in terms of reducing stress, work hazards and encouraging efficiency and safety. The absence of ergonomics in furniture designed results in mismatch and constrained posture. Sadly, the awareness and application of ergonomic principles in healthcare furniture remain significantly limited, particularly at the Nigerian primary care level (Obaseki and Erhabor, 2023; Bolarinwa and Kumapayi, 2023). Ergonomic mismatch occurs when furniture dimensions and support features do not match user's anthropometric measurements, consequently the furniture fails to provide proper posture and support to the occupant (Isapka and Omorodion, 2019; Aiyegbusi et al., 2023). Common mismatched elements reported in office seating including seat height, backrest and armrest dimensions, which together determine fit and support for the pelvis, lumbar spine, and thighs. According to Oche and Adamu (2013), sustained awkward sitting from incorrect seat height/depth forces compensatory postures (slouched lumbar spine or forward head) that concentrate load on lumbar and cervical tissues. Also, Garosi et al. (2025), agrees that the lack of appropriate lumbar support and improper seat depth reduce pelvic stability and increase soft-tissue strain in the lower back. Field studies document high rates of discomfort and MSD symptoms in populations using non-anthropometric furniture, with neck, shoulder and lower back complaints prominent (Isapka and Omorodion, 2019; Aiyegbusi et al., 2023).

Anthropometry is the reference point for solving any mismatch issue in furniture design. Anthropometry, stemming from the Greek words '*anthropos*' (human) and '*metreo*' (to measure), is fundamentally the science of human measurement. According to Del Prado-Lu (2007), anthropometry is "the science of measurement and the art of application that establishes the physical geometry, mass properties and strength capabilities of the human body". Because anthropometric measurements vary across populations, geographic regions, age groups, and professional categories, the direct transfer of furniture dimensions across backgrounds is inappropriate and potentially harmful (Smardzewski, 2015; Malone and Dellinger, 2011). In Nigeria however, the anthropometric database for healthcare workers (particularly at the primary care level) remains spares, driving continued reliance on non-contextualised furniture that maybe ergonomically unsuitable for local users (Ismaila et al., 2013). It is therefore critical to create an anthropometric data of primary healthcare workers, as a baseline for assessing the existing furniture available for use by the worker.

The practice of procuring standardised, mass-produced furniture without recourse to the anthropometric profiles of end users has been widely documented in Nigerian public institutions (Taifa and Desai, 2017; Ibrahim et al., 2023; Oladapo et al., 2024). In healthcare settings, this one-size-fits-all approach creates furniture-user mismatches that expose HCWs to prolonged postural stress, reduced productivity, and heightened risk of MSDs (Obaseki and Erhabor, 2023; Olumide et al., 2024). At the primary healthcare level, where facilities are often underresourced and HCWs may spend extended periods at workstations with minimal respite, the consequences of ergonomic mismatch are particularly acute. Despite a growing body of research on ergonomic mismatch in educational settings in Nigeria (Ismaila et al., 2013; Aiyegbusi et al., 2023; Icha and Adewole, 2026), no comparable study has targeted PHCFs, leaving a critical evidence gap. This study provides gender-disaggregated anthropometric data and evaluates existing furniture mismatch in public primary healthcare facilities in Calabar Metropolis, Nigeria, with a view to informing ergonomically appropriate design standards and procurement policies at the primary care level.

Materials and Methods

Study Area and Participants

This study was conducted in 25 PHFs (13 PHFs in Calabar Municipal LGA and 12 PHFs in Calabar South LGA) in Calabar Metropolis, Nigeria. These facilities represent major first point contacts for individuals seeking medical assistance and serving as foundation of healthcare delivery systems and employing a range of healthcare professionals. Table 1 presents the distribution of selected HCFs with names, LGAs and ward.

The study population comprised a total of 219 healthcare workers across both Local Government Areas. The required sample size was determined using Cochran's sample size formula (Equation 1) with finite population correction in accordance with Fidelis et al., (2018):

$$n = \frac{NZ^2P(1-P)}{e^2(N-1)+Z^2P(1-P)} \quad (1)$$

Where:
n = sample size, N = population size (219), Z = standard normal deviate at 95% confidence level (1.96), P = estimated population proportion (0.5), e = margin of error (0.05).

A required sample size of 140 was obtained. However, a total of 145 healthcare workers having 47 males (32.4%) and 98 females (67.6%) recruited to enhance statistical reliability.

Table 1. Distribution of Selected Primary Healthcare Facilities in Calabar Metropolis

Ward	S/N	Facilities in Calabar Municipal	Ward	S/N	Facilities in Calabar South
1. Akim	1	Akim Primary Health Centre	ward 1	1	Bogobiri Primary Health Care Centre
2. Edim Otop	2	Atimbo Health Post	ward 2	2	Eyamba Primary Health Care Centre
3. Ediba	3	Ediba Primary Health Centre	ward 3	3	Family Planning Coordination Unit Clinic
4. Big Qua	4	Big Qua Primary Health Centre	ward 4	4	Anderson Primary Health Care Centre
5. Diamond	5	Ekorinim Health Centre	ward 6	5	Mary Magdalene Primary Health Care Centre
6. Ikot Ishie	6	Ikot Ishie Primary Health Care Centre	ward 8	6	Esierebom Primary Health Care Centre
7. Kasuk	7	Kasuk Primary Health Care Centre	ward 9	7	Nysc Community Health Centre/Community Based Health Centre
	8	Federal Housing Health Post	ward 10	8	Nelson Mandela Primary Health Care Centre
	9	Ikot Ansa Primary Health Care Centre	ward 11	9	Anantigha Primary Health Care Centre
8. Ikot Effanga	10	Ikot Effanga Mkpa Primary Health Care Centre		10	Calabar South Council Clinic
9. Ikot Effanga	11	Ikot Enebong Health Centre	ward 12	11	Ekpo Abasi Primary Health Care Centre
10. Ikot Omin	12	Enima Omin Health Post		12	Uwanse Health Centre
	13	Ikot Ekpo Health Centre			

Sampling Technique

A stratified random sampling approach was employed to ensure representation across different professional groups and departments within the healthcare facilities. Participants were randomly selected within each stratum to minimize sampling bias in accordance with Perumal, (2023).

Ethical Considerations

Ethical approval was obtained from the Cross River State Health Research Ethics Committees (CRS-HREC) with record No. CRS/MH/HREC/2024/VPL.2/065 and the Cross River State Primary Health Care Development Agency, Calabar (approval no. CRS/PHCDA/S/71/277). All participants provided informed written consent prior to data collection. Participation was voluntary, and confidentiality of all collected data was strictly maintained. Data collection period was from September 2024 to November 2024.

Anthropometric Measurements

Thirteen anthropometric dimensions relevant to furniture design were measured in accordance with ISO 7250-1 (2017) standards. This included stature, sitting height, shoulder height (sitting), popliteal height, hip breadth, elbow height (sitting), buttock–popliteal length, buttock–knee length, thigh clearance, eye height (sitting), shoulder breadth, knee height, and vertical reach as described by (Sejdiu et al., 2023; Saha et al., 2024). Measurements were taken using standard anthropometric instruments, including a stadiometer, anthropometer, measuring tape, and weighing scale. All instruments were calibrated prior to data collection to ensure accuracy.

Participants were seated in an upright posture on an adjustable chair with knees flexed at approximately 90°, feet resting on a flat surface, and arms positioned naturally. Each measurement was taken by trained personnel to ensure consistency and reliability as depicted in Figure (1). Definitions of the anthropometric dimensions measured in accordance with ISO 7250 (2017) are provided in Table 2.

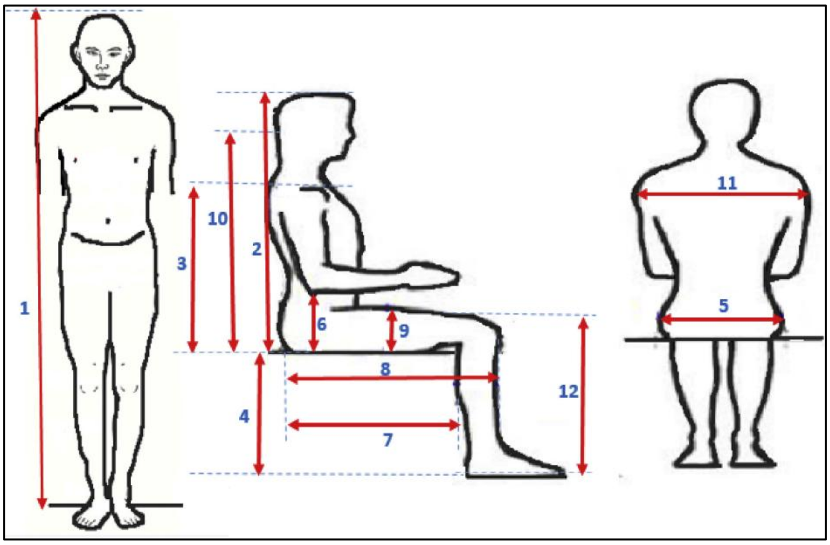


Figure 1. Anthropometric Data Required in Furniture Design.

Table 2. Definitions of anthropometric dimensions measured in accordance with ISO 7250

` S/No.	According to ISO 7250	Anthropometric dimension	Symbol	Description of the body dimensions according to ISO 7250
0	4.1.1	Body mass (weight)	BM	Total mass (weight of the body) which was measured with the help of weighing scale
1	4.1.2	Stature (body height)	STH	Vertical distance from the floor to the highest point of the head (vertex)
2	4.2.1	Sitting height (erect)	SH	Vertical distance from a horizontal sitting surface to the highest point of the head (vertex)
3	4.2.4	Shoulder height, sitting	SSH	Vertical distance from a horizontal sitting surface to the acromion
4	4.2.12	Lower leg length (popliteal height)	PH	Vertical distance from the foot-rest surface to the lower surface of the thigh immediately behind the knee, bent at right angle
5	4.2.11	Hip breadth, sitting	HB	Breadth of the body measured across the widest portion of the hips
6	4.2.5	Elbow height, sitting	SEH	Vertical distance from a horizontal sitting surface

				to the lowest bony point of the elbow bent at a right angle with the forearm horizontal
7	4.4.6	Buttock-popliteal length	BPL	Horizontal distance from the hollow of the knee to the rearmost point of the buttock
8	4.4.7	Buttock-knee length	BKL	Horizontal distance from the foremost point of the knee-cap to the rearmost point of the buttock
9	4.2.13	Thigh clearance	TC	Vertical distance from the sitting surface to the highest point on the thigh
10	4.2.2	Eye height, sitting	SEH	Vertical distance from a horizontal sitting surface to the outer corner of the eye
11	4.2.9	Shoulder (bideltoid) breadth	SB	Distance across the maximum lateral protrusions of the right and left deltoid muscles
12	4.2.14	Knee height	KH	Vertical distance from the floor to the highest point of the superior body of the patella
13	4.2.17	Vertical reach height sitting	VR	Horizontal distance from the shoulder to longest finger with subject sitting erect

Furniture Dimension Assessment

Dimensions of existing furniture used within the facilities were measured, including four armchair types, two armless chair types, and fifteen table types. Key parameters relevant to ergonomic evaluation—seat height, seat depth, seat width, backrest height, armrest height, and table height—were extracted for mismatch analysis (Taifa and Desai, 2017). The complete details of furniture dimension and data set are available for further exploration and can be found in Icha and Adewole (2026). The measured chair dimensions are presented in Table 3, while the measured table heights are presented in Table 4.

Table 3. PHCFs Furniture Dimensions in mm (Icha and Adewole, 2026)

	Chair Type 1 (mm)	Chair Type 2 (mm)	Chair Type 5 (mm)	Chair Type 6 (mm)	Chair Type 3 (mm) (armless)	Chair Type 4 (mm) (armless)
Seat Height (SH)	415	450	330	550	420	450
Seat Depth (SD)	670	480	340	457	500	450
Seat Width (SW)	855	530	340	120	460	505
Backrest Width (BRW)	855	570	345	110	460	500
Backrest Height to Seat (BRHS)	725	450	990	270	435	650
Arm Rest to Seat Surface Height	200	175	70	190	-	-

Table 4. PHCFs Table Heights in mm (Icha and Adewole, 2026)

	Table 1 (mm)	Table 2 (mm)	Table 3 (mm)	Table 4 (mm)	Table 5 (mm)	Table 6 (mm)	Table 7 (mm)	Table 8 (mm)
Table Height	770	760	740	930	760	804	805	805
	Table 9 (mm)	Table 10 (mm)	Table 11 (mm)	Table 12 (mm)	Table 13 (mm)	Table 14 (mm)	Table 15 (mm)	
Table Height	670	790	710	850	760	789	650	

Mismatch Analysis

Ergonomic compatibility between user anthropometry and furniture dimensions was evaluated using established mismatch equations derived from previous studies (Taifa and Desai, 2017). These equations define acceptable dimensional ranges for furniture design based on anthropometric parameters. A match was recorded when furniture dimensions fell within the acceptable range; otherwise, a mismatch was classified as either lower or upper mismatch (Sejdiu *et al*, 2023). The seat height of each participant was compared with the popliteal height using equation (2), the seat width against the hip breadth using equation (3). The seat depth against the buttock popliteal length using equation (4). the Backrest Height Sitting is compared with the Shoulder Height as in equation (5), the Armrest Seat Height is compared against the Elbow Height as in equation (6), Armrest seat Height is compared against Seating Elbow Height in equation (7), and adopted from Lee (2019) and Altaboli et. al., (2023).

$$(PH + ST)\cos(30\circ) \leq SH \leq (PH + ST)\cos(5\circ) \quad (2)$$

Where: SH is Seat Height (mm), PH is popliteal height, ST is shoe sole thickness considered as 30mm.

$$(1.10 \times HB) \leq SW \leq (1.30 \times HB) \quad (3)$$

Where: SW is Seat Width, HB is Hip Breadth,

$$(0.80 \times BPL) \leq SD \leq (0.95 \times BPL) \quad (4)$$

Where: SD is Seat Depth, BPL is Buttock popliteal Length,

$$(0.60 \times SSH) \leq BH \leq (0.80 \times SSH) \quad (5)$$

Where: BH is Backrest Height, SSH is Shoulder Height Sitting,

$$SEH - 100 \leq ASH \leq SEH + 50 \quad (6)$$

Where: ASH is Armrest Seat Height, SEH is Sitting Elbow Height,

$$max\,(SEH + [(PH + ST)\cos 30°], (KH + ST) + DC + BT + TTF) \leq TH \leq (0.8517EH) + (0.1483SSH) + [(PH + ST)\cos 5°] \quad (7)$$

Where: TH is Table Height, BT is Board thickness (20mm), TTF is Table Top Frame (70mm), SEH is Sitting Elbow Height, PH is Popliteal Height Sitting, ST is Sole thickness (30mm), KH is Knee Height, DC is Desk Clearance (20mm), SSH is Shoulder height, Sitting.

Data Analysis

Collected data were analysed using descriptive statistics, including mean, standard deviation, minimum, maximum, and percentile values (5th, 50th, and 95th). Correlation analysis was performed to assess relationships between anthropometric variables. Statistical analyses were conducted using SPSS (version 16.0), while Microsoft Excel and Python (version 3.10) were used for data visualization and additional analytical procedures. All anthropometric measurements were expressed in millimetres (mm), except body weight, which was recorded in kilograms (kg).

Result and Discussions

Anthropometry Measurement

Tables 5, 6 and 7 presents' descriptive statistics of all thirteen anthropometric parameters measured for the combined, male and female HCW cohorts in primary facilities, respectively. The combined sample (n = 145; 47 males, 98 females) recorded a mean stature of 1643.6 mm (SD = 78.5 mm), ranging from 1500 mm to 1840 mm, with 5th and 95th percentile values of 1540 mm and 1810 mm, respectively. When disaggregated by sex, male HCWs were taller on average (mean = 1722.7 mm, SD = 63.7 mm) than their female counterparts (mean = 1605.7 mm, SD = 52.5 mm), consistent with established sex-based anthropometric dimorphism reported in Nigerian and sub-Saharan African populations (Ismaila et al., 2013; Oladapo et al., 2024). Popliteal height (PH), a critical determinant of seat height compatibility, recorded a combined mean of 435.0 mm (SD = 50.0 mm), with male values (mean = 461.1 mm, SD = 62.8 mm) considerably higher than female values (mean = 422.5 mm, SD = 36.8 mm). This sex-based difference has direct implications for furniture compatibility, as a uniform seat height that accommodates males is likely to impose lower mismatch for shorter users and vice versa. Similar disparities in popliteal height between sexes have been documented in Nigerian university populations (Ismaila et al., 2013) and Filipino manufacturing workers (Del Prado-Lu, 2007), reinforcing that anthropometric variability necessitates sex-disaggregated analysis in furniture design.

Hip breadth (HB), which governs seat width requirements, recorded a combined mean of 409.7 mm (SD = 46.2 mm), with females recording a higher mean (419.6 mm) than males (388.9 mm), a pattern consistent with female pelvic morphology. The buttock-popliteal length (BPL), used to evaluate seat depth suitability, averaged 476.6 mm (SD = 26.0 mm) for the combined group, with males (480.0 mm) slightly exceeding females (474.9 mm).

Elbow height sitting (SEH), which defines the ergonomic range for armrest height, averaged 220.4 mm (SD = 36.4 mm) overall, with females recording a marginally higher mean (227.6 mm) compared to males (205.5 mm). Shoulder height sitting (SSH), the reference dimension for backrest height, averaged 640.1 mm (SD = 42.2 mm) across the combined cohort. Importantly, the 5th-95th percentile ranges across key dimensions were wide - for example, PH ranged from 370 mm to 530 mm in the combined cohort - underscoring the substantial within-sample anthropometric variability. This variability reinforces the argument advanced by Smardzewski (2015) and Malone and Dellinger (2011) that one-size-fits-all furniture procurement, common in Nigerian public institutions (Ibrahim et al., 2023), is fundamentally inadequate to serve a diverse workforce. A normal distribution curve is observed for the combined male and female anthropometry displayed in Figure (2).

Table 5. Anthropometric measures of male and Female Primary HCWs

S/N	Body Dimension	Min	Max	M & F Percentiles			Mean	SD
				5th	50th	95th		
0	Weight	41.0	106.0	47	65	91	66.8	13.2
1	Stature (mm)	1500	1840	1540	1640	1810	1643.6	78.5
2	Sitting height (mm)	670	920	760	830	890	829.2	43.4
3	Shoulder height, sitting (mm)	510	730	580	640	710	640.1	42.2
4	Lower Leg Length (Popliteal height) (mm)	360	620	370	430	530	435.0	50.0
5	Hip Breadth, Sitting (mm)	300	510	340	410	490	409.7	46.2
6	Elbow Height, Sitting (mm)	140	310	160	220	290	220.4	36.4
7	Buttock-popliteal Length/Seat depth) (mm)	420	550	430	470	520	476.6	26.0
8	Buttock-knee length (mm)	490	670	513	580	637	579.3	35.3
9	Thigh clearance (mm)	130	230	140	170	220	177.2	24.9
10	Eye height, sitting (mm)	600	850	643	732	800	731.5	46.1
11	Shoulder (bideltoid) breadth (mm)	350	550	380	430	527	436.9	43.6
12	Knee height (mm)	440	690	490	540	680	551.4	48.7
13	Vertical reach height sitting (mm)	1080	1390	1140	1250	1377	1250.6	68.2

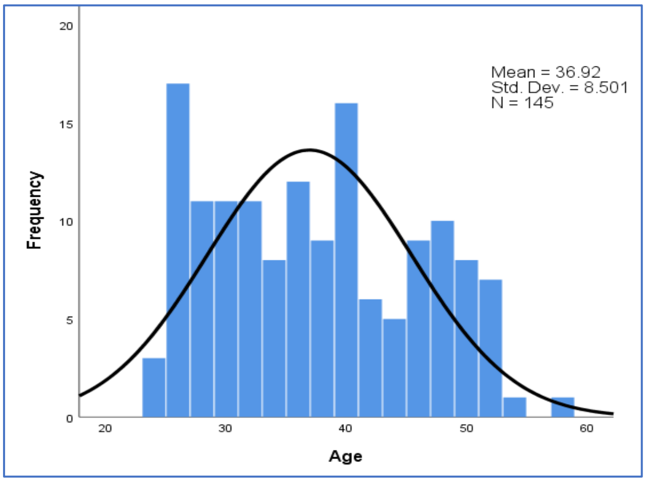
Table 6. Anthropometric measures of male Primary HCWs

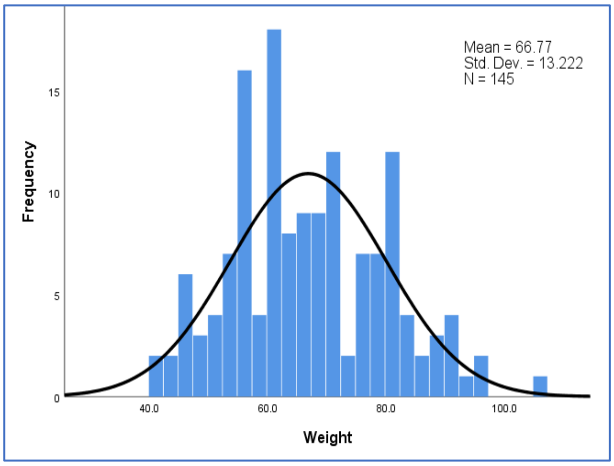
S/N	Body Dimension	Min	Max	Male Percentiles			Mean	SD
				5th	50th	95th		
0	Weight	58	92	59.3	76	89.7	74.36	9.44
1	Stature (mm)	1620	1840	1640	1710	1827	1722.66	63.66
2	Sitting height (mm)	750	900	780	840	890	836.81	37.36
3	Shoulder height, sitting (mm)	590	720	600	640	710	653.62	38.47
4	Lower Leg Length (Popliteal height) (mm)	400	620	400	440	590	461.06	62.81
5	Hip Breadth, Sitting (mm)	340	460	340	390	450	388.94	36.25
6	Elbow Height, Sitting (mm)	150	260	150	200	260	205.53	32.42
7	Buttock-popliteal Length/Seat depth) (mm)	430	550	430	480	530	480.00	32.37

8	Buttock-knee length (mm)	500	650	530	580	640	578.30	34.60
9	Thigh clearance (mm)	150	230	153	180	220	186.38	20.37
10	Eye height, sitting (mm)	600	810	680	750	800	742.85	43.30
11	Shoulder (bideltoid) breadth (mm)	390	550	410	470	550	472.77	46.52
12	Knee height (mm)	490	690	513	580	690	588.09	59.22
13	Vertical reach height sitting (mm)	1150	1390	1163	1290	1390	1286.38	71.09

Table 7. Anthropometric measures of female Primary HCWs

S/N	Body Dimension	Min	Max	Female Percentiles			Mean	SD
				5th	50th	95th		
0	Weight	41	106	45.85	60	85.9	63.12	13.26
1	Stature (mm)	1500	1730	1529.2	1602.5	1710	1605.73	52.54
2	Sitting height (mm)	670	920	760	830	890	825.61	45.73
3	Shoulder height, sitting (mm)	510	730	548.5	635	701.5	633.67	42.51
4	Lower Leg Length (Popliteal height) (mm)	360	530	370	420	491.5	422.45	36.84
5	Hip Breadth, Sitting (mm)	300	510	348.5	420	500	419.59	47.36
6	Elbow Height, Sitting (mm)	140	310	180	220	300	227.55	36.21
7	Buttock-popliteal Length/Seat depth) (mm)	420	520	440	470	511.5	474.90	22.39
8	Buttock-knee length (mm)	490	670	518.5	580	630	579.80	35.81
9	Thigh clearance (mm)	130	230	140	170	220	172.76	25.76
10	Eye height, sitting (mm)	600	850	640	730	800	726.02	46.63
11	Shoulder (bideltoid) breadth (mm)	350	500	370	420	470	419.69	29.51
12	Knee height (mm)	440	600	488.5	535	581.5	533.88	29.97
13	Vertical reach height sitting (mm)	1080	1380	1140	1230	1350	1233.37	59.93





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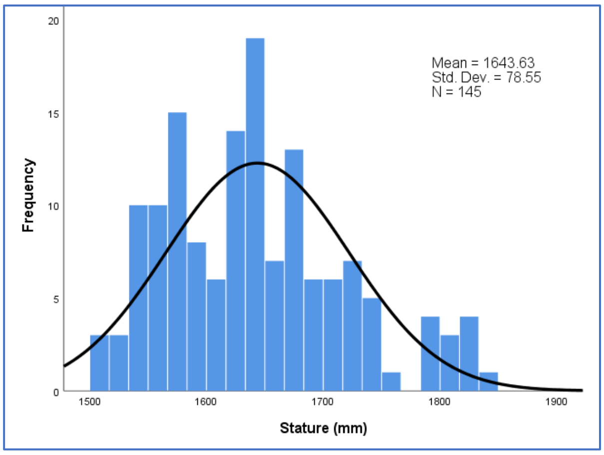

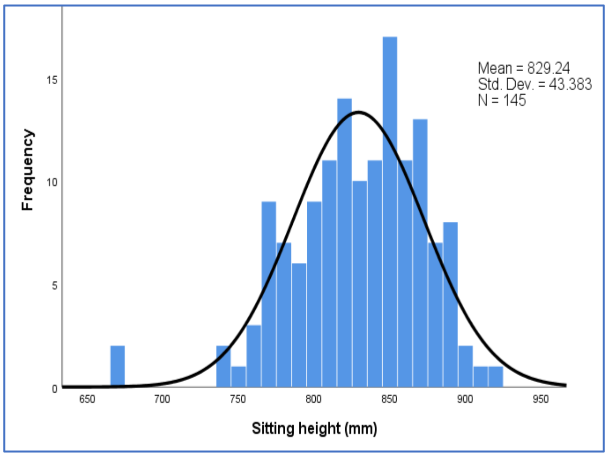

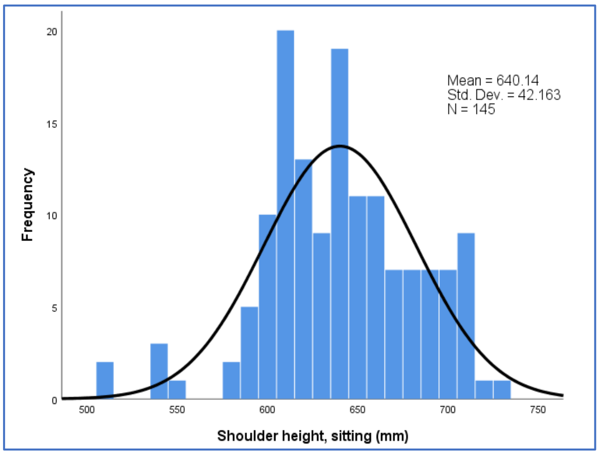

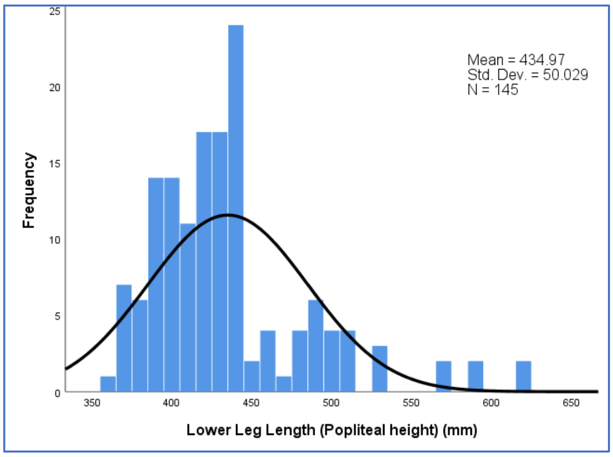

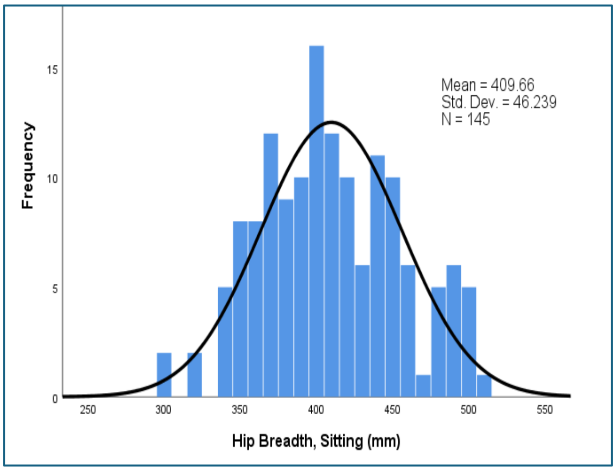

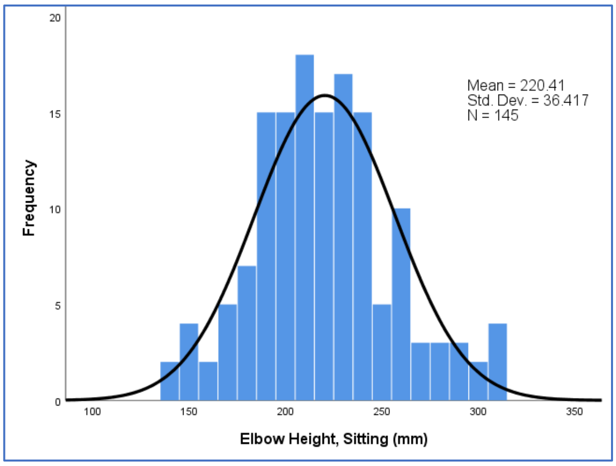

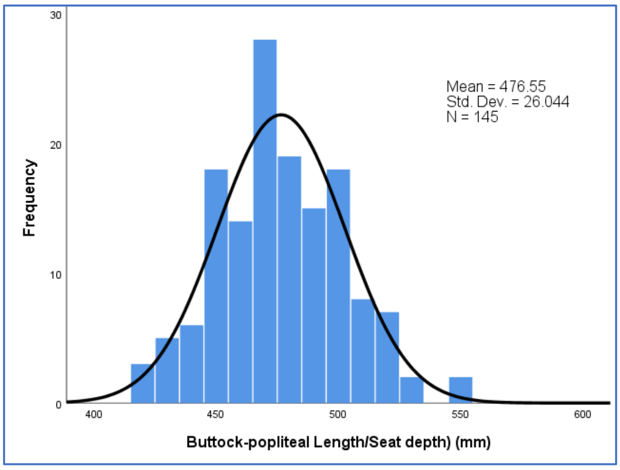

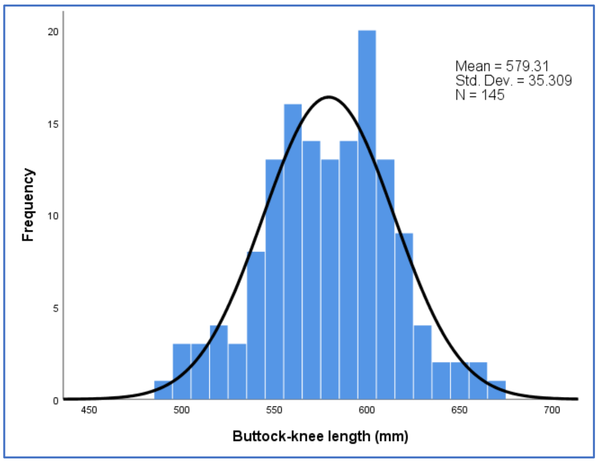

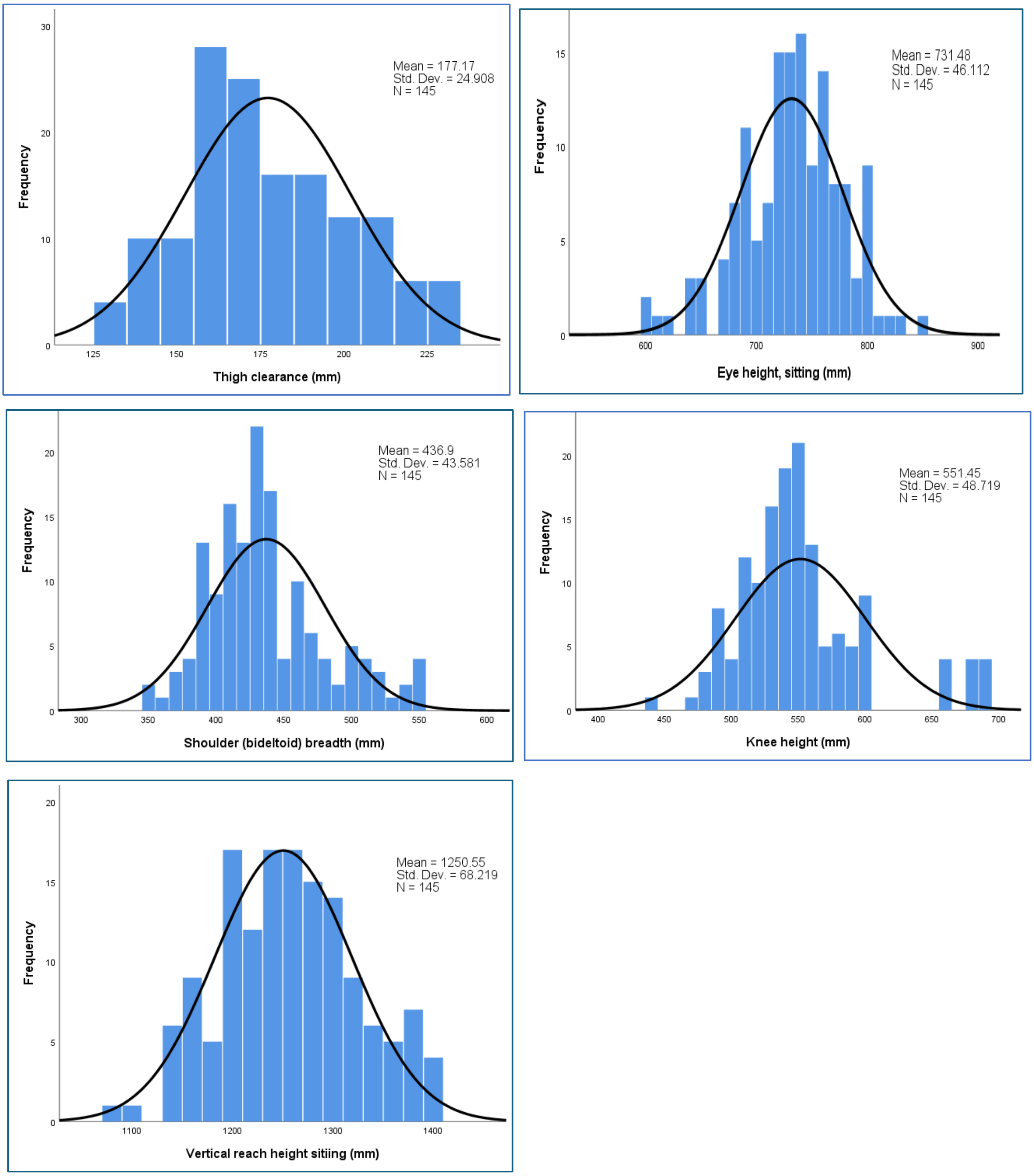

Figure 2. Normal Distribution Curve for Male and Female anthropometric Data of Primary HCWs

Correlation Analysis

Tables 8 and 9 present the Pearson correlation matrices for male (n = 47) and female (n = 98) primary HCWs respectively. In the male cohort, the strongest correlations were observed between hip breadth and shoulder breadth (r = 0.633), buttock-popliteal length and shoulder breadth (r = 0.593), and buttock-popliteal length and buttock-knee length (r = 0.572). Popliteal height showed moderate positive correlations with shoulder height sitting (r = 0.441) and hip breadth (r = 0.456). Notably, thigh clearance and eye height sitting showed a moderate positive relationship (r = 0.521), and stature showed a negative correlation with eye height sitting (r = -0.369), which may reflect postural variation during seated measurement. Among females, the correlation structure differed markedly from males, reflecting the greater morphological diversity in the female subsample. Stature correlated most strongly with popliteal height (r = 0.543), shoulder height sitting (r = 0.390), and sitting height (r = 0.338). Eye height sitting was moderately correlated with sitting height (r = 0.509) and shoulder height sitting (r = 0.495). These patterns suggest that for female HCWs, stature is a better predictor of lower-limb and seated-posture dimensions than for males, where lateral breadth dimensions showed stronger intercorrelations. The differential correlation structures between sexes confirm the necessity of sex-disaggregated furniture design standards. As noted by Del Prado-Lu (2007), anthropometric measurements co-vary differently across populations and subgroups, and applying a single dimensional standard across both sexes risks systematic mismatches for a significant portion of users.

Table 8. Correlation coefficients between measurements for male Primary HCWs (n = 47)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1		-0.095	0.065	0.092	0.210	0.206	0.090	0.133	-0.237	-0.369	0.034	0.065	-0.013
2	-0.095		0.060	0.204	-0.017	0.147	0.069	0.398	0.228	0.225	0.076	-0.031	0.363
3	0.065	0.060		0.441	0.481	0.185	0.363	0.095	0.032	-0.105	0.227	-0.229	-0.306
4	0.092	0.204	0.441		0.456	0.031	0.260	0.437	0.310	0.329	0.381	0.191	-0.359
5	0.210	-0.017	0.481	0.456		0.344	0.480	0.418	0.193	0.029	0.633	0.188	-0.326
6	0.206	0.147	0.185	0.031	0.344		0.286	0.187	0.087	-0.234	0.339	0.193	-0.224
7	0.090	0.069	0.363	0.260	0.480	0.286		0.572	-0.061	0.011	0.593	0.193	-0.091
8	0.133	0.398	0.095	0.437	0.418	0.187	0.572		0.035	0.014	0.402	0.268	0.025
9	-0.237	0.228	0.032	0.310	0.193	0.087	-0.061	0.035		0.521	0.224	0.445	-0.124
10	-0.369	0.225	-0.105	0.329	0.029	-0.234	0.011	0.014	0.521		0.143	0.284	0.169
11	0.034	0.076	0.227	0.381	0.633	0.339	0.593	0.402	0.224	0.143		0.243	-0.239
12	0.065	-0.031	-0.229	0.191	0.188	0.193	0.193	0.268	0.445	0.284	0.243		0.135
13	-0.013	0.363	-0.306	-0.359	-0.326	-0.224	-0.091	0.025	-0.124	0.169	-0.239	0.135	

Table 9. Correlation coefficients between measurements for female Primary HCWs (n = 98)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1		0.338	0.390	0.543	0.125	0.270	-0.044	0.232	0.124	0.331	0.012	0.341	0.426
2	0.338		0.467	-0.018	0.316	0.361	-0.014	0.153	0.191	0.509	0.174	0.267	0.224
3	0.390	0.467		0.195	0.410	0.521	0.012	0.130	0.253	0.495	0.199	0.115	0.331
4	0.543	-0.018	0.195		0.162	0.127	-0.026	0.114	0.000	-0.119	-0.231	0.070	0.082
5	0.125	0.316	0.410	0.162		0.454	0.000	0.250	0.463	0.041	0.365	0.067	-0.152
6	0.270	0.361	0.521	0.127	0.454		-0.009	0.341	0.348	0.163	0.174	-0.083	0.077
7	-0.044	-0.014	0.012	-0.026	0.000	-0.009		0.294	0.232	0.156	0.187	0.201	-0.109
8	0.232	0.153	0.130	0.114	0.250	0.341	0.294		0.244	0.039	-0.040	-0.038	0.084
9	0.124	0.191	0.253	0.000	0.463	0.348	0.232	0.244		0.298	0.341	0.180	-0.011
10	0.331	0.509	0.495	-0.119	0.041	0.163	0.156	0.039	0.298		0.080	0.326	0.332
11	0.012	0.174	0.199	-0.231	0.365	0.174	0.187	-0.040	0.341	0.080		0.094	-0.003
12	0.341	0.267	0.115	0.070	0.067	-0.083	0.201	-0.038	0.180	0.326	0.094		0.348
13	0.426	0.224	0.331	0.082	-0.152	0.077	-0.109	0.084	-0.011	0.332	-0.003	0.348	

Mismatch Analysis

Chair Mismatch (Armchairs)

Table 10 and Figure 3a and 3b presents the match and mismatch percentages for the four armchair types (Chair Types 1, 2, 5, and 6) in PHCFs. The results reveal alarmingly low match rates across nearly all dimensions and chair types, particularly for Chair Types 1 and 5.

Seat Height: Chair Type 1 (SH = 415 mm) produced 0% match for both male and female HCWs against popliteal height, with predominant upper mismatch - indicating that the chair is too high relative to users' lower leg length - for 63% of males and 76.9% of females. Chair Type 5 (SH = 330 mm) produced 100% lower mismatch for males and females alike, as its seat height falls below the lowest acceptable range for all users. Chair Type 6 (SH = 550 mm) produced 85.2% upper mismatch in males and 98.8% in females, being far too high for the study population. Only Chair Type 2 (SH = 450 mm) produced any meaningful match: 33.3% for males and 23.1% for females, though mismatch still exceeded 76% of users in both groups. These findings are consistent with Oche and Adamu (2013), who reported that incorrect seat height forces compensatory postures such as slouched lumbar spine and forward head position, concentrating mechanical load on lumbar and cervical tissues. Similarly, Garosi et al. (2025) demonstrated that improper seat height is a primary driver of soft-tissue strain in the lower back. The near-complete failure of Chair Types 1, 5, and 6 on seat height underscores the severity of the ergonomic deficit at the primary care level in Calabar Metropolis.

Seat Width: Chair Type 1 (SW = 855 mm) produced 100% upper mismatch for both sexes - its seat is too wide relative to hip breadth for all users. Chair Type 5 (SW = 340 mm) produced 100% lower mismatch for males and 98.8% for females, being too narrow. Chair Type 2 achieved partial compatibility, with 29.6% match for males and 50% for females. These results are comparable to findings by Isapka and Omorodion (2019) and Aiyegbusi et al. (2023), who documented widespread seat width mismatches in Nigerian educational furniture that contributed to postural instability and musculoskeletal discomfort.

Seat Depth: Chair Type 1 (SD = 670 mm) produced 100% upper mismatch across both sexes, its seat depth exceeding buttock-popliteal length for all users - a condition that reduces pelvic stability and compresses the popliteal space. Chair Type 5 (SD = 340 mm) generated 100% lower mismatch for males and 97.7% for females. Chair Type 2 recorded 22.2% match in males and only 5.8% in females, while Chair Type 6 achieved 40.7% match in males and 34.9% in females. Garosi et al. (2025) affirm that improper seat depth reduces pelvic stability and increases soft-tissue strain, while Obaseki and Erhabor (2023) reported that Nigerian tertiary health workers already operate under ergonomically deficient seating conditions, a pattern this study confirms extends to the primary care level.

Backrest Height: Chair Type 1 produced 100% upper mismatch for both sexes, with its oversized backrest height (BRHS = 725 mm from seat level) exceeding the ergonomic range for all users. Chair Type 5 similarly produced 100% upper mismatch owing to its extreme backrest height of 990 mm. Chair Type 6 (BRHS = 270 mm) produced 100% lower mismatch, its backrest being too short to provide any meaningful lumbar or dorsal support. Only Chair Type 2 (BRHS = 450 mm) achieved satisfactory match: 100% for males and 95.3% for females - a notable finding suggesting that Chair Type 2 is designed closest to the ergonomic requirements of this cohort for backrest support. The importance of adequate lumbar support is well documented; Kamijantono et al. (2024) linked inadequate backrest support directly to musculoskeletal disorder (MSD) risk in healthcare work environments, and Adiga (2023) identified work-support facilities as central to reducing workplace hazards.

Armrest Height: Chair Type 1 yielded only 14.8% match in males and 7.7% in females, with lower mismatch dominant (48.1% males, 76.9% females), indicating armrests set too low relative to elbow height. Chair Type 2 performed worse, with 7.4% and 5.8% match for males and females respectively, and near-total lower mismatch (74.1% males, 94.2% females). Chair Type 5 produced 100% lower mismatch for both sexes, its armrests (70 mm above seat) being functionally non-supportive. Chair Type 6 achieved 11.1% and 9.3% match for males and females respectively. Across all four armchair types, armrest heights are predominantly below the ergonomic range defined by sitting elbow height. This is a critical finding, as Isapka and Omorodion (2019) established that insufficient armrest support forces users to elevate their shoulders or adopt asymmetric postures, increasing neck and shoulder MSD risk - a consequence particularly concerning for healthcare workers who require fine motor stability during clinical procedures.

Table 10. Match and Mismatch Percentages of Existing Arm Chairs in PHCFs of CM

		Chair Type 1			Chair Type 2		
		Match (%)	Lower Mismatch (%)	Upper Mismatch (%)	Match (%)	Lower Mismatch (%)	Upper Mismatch (%)
PH vs SH	Male	0	37	63	33.3	29.6	37
	Female	0	23.1	76.9	23.1	15.4	61.5
HB vs SW	Male	0	0	100	29.6	0	70.4
	Female	0	0	100	50	17.3	32.7
BPL vs SD	Male	0	0	100	22.2	0	77.8
	Female	0	0	100	5.8	0	94.2
SSH vs BRH	Male	0	0	100	100	0	0
	Female	0	0	100	95.3	0	4.7

EH vs ASH	Male	14.8	48.1	37	7.4	74.1	18.5
	Female	7.7	76.9	15.4	5.8	94.2	0
		Chair Type 5			Chair Type 6		
		Match (%)	Lower Mismatch (%)	Upper Mismatch (%)	Match (%)	Lower Mismatch (%)	Upper Mismatch (%)
PH vs SH	Male	0	100	0	11.1	3.7	85.2
	Female	0	100	0	1.2	0	98.8
HB vs SW	Male	0	100	0	0	100	0
	Female	1.2	98.8	0	0	100	0
BPL vs SD	Male	0	100	0	40.7	0	59.3
	Female	2.3	97.7	0	34.9	0	65.1
SSH vs BRH	Male	0	0	100	0	100	0
	Female	0	0	100	0	100	0
EH vs ASH	Male	0	100	0	11.1	63	25.9
	Female	0	100	0	9.3	84.9	5.8

(a)

(b)

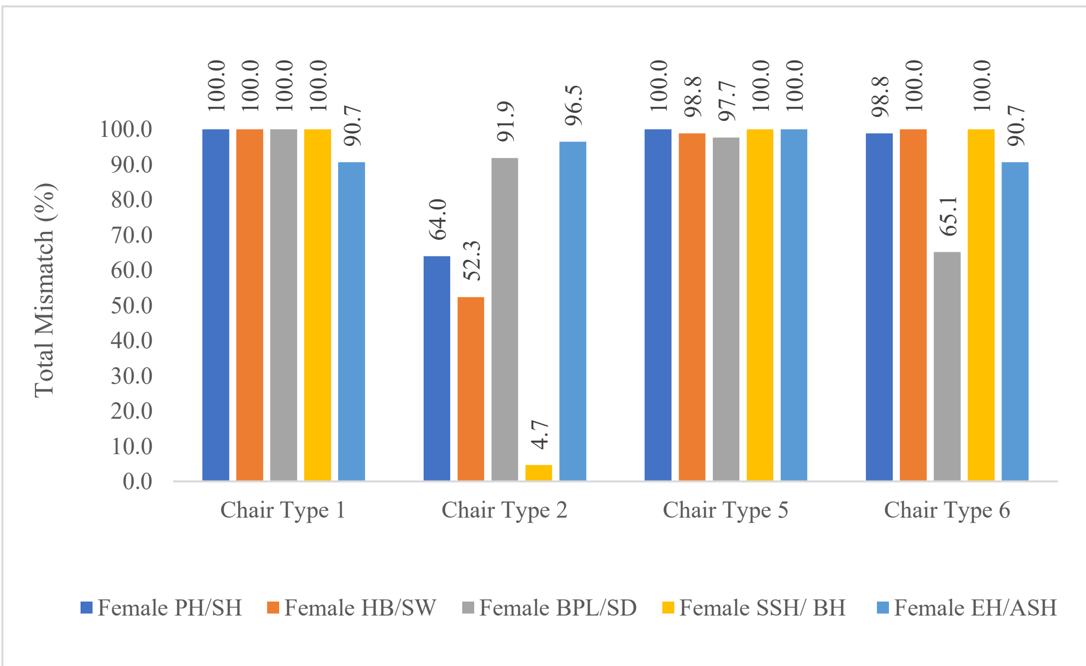

Figure 3a. Armed Chair Mismatch for Male HCWs in PHCFs of Calabar Metropolis, **(b)** Armed Chair Mismatch for Female HCWs in PHCFs of Calabar Metropolis

Chair Mismatch (Armless Chairs)

Table 11 and Figure 4a and 4b presents mismatch results for Chair Types 3 and 4. The armless chairs showed notably better match rates compared to the armchairs across most dimensions.

Seat Height: Chair Type 3 (SH = 420 mm) achieved the highest seat height match rate of any chair in the study: 66.7% for males and 52.3% for females - a marked improvement over all armchair types. Chair Type 4 (SH = 450 mm) achieved 33.3% match in males and 36% in females. Both chairs exhibited a balanced distribution of lower and upper mismatches, reflecting that their seat heights straddle the population mean popliteal height more effectively. This finding shows that standard armless institutional chairs often approximate user popliteal height more closely due to their conventional dimensions.

Seat Width: Chair Type 3 (SW = 460 mm) achieved 55.6% match in males and 45.3% in females. Chair Type 4 (SW = 505 mm) performed similarly, with 48.1% match for males and 54.7% for females - the highest seat width match recorded across all chair types. Both armless chairs substantially outperformed the armchairs on this dimension, consistent with the fact that their widths more closely correspond to the mid-range hip breadth values of the cohort.

Seat Depth: Chair Type 3 (SD = 500 mm) produced predominantly upper mismatch (92.6% males, 100% females), its depth exceeding buttock-popliteal length for most users. Chair Type 4 (SD = 450 mm) performed considerably better, achieving 51.9% match in males and 47.7% in females - the highest seat depth match among all six chair types - with approximately equal proportions of lower and upper mismatch among non-matching users. This suggests Chair Type 4 presents the most dimensionally appropriate seat depth for the study population.

Backrest Height: Chair Type 3 (BRHS = 435 mm) achieved 100% match for males and 95.3% for females - a remarkable result that mirrors the performance of Chair Type 2 on this dimension. In contrast, Chair Type 4 (BRHS = 650 mm) produced 100% upper mismatch for both sexes, indicating its backrest extends too high above the shoulder height of all users. The discrepancy between Chair Types 3 and 4 on backrest height, despite both being armless chairs of broadly similar construction, illustrates that even within a single furniture category, dimensional variation can produce dramatically different ergonomic outcomes - underscoring the need for empirical assessment rather than categorical assumptions about furniture suitability.

Overall, the mismatch analysis of chairs reveals a pattern consistent with the broader Nigerian literature: furniture procured for public healthcare settings is not selected on the basis of anthropometric compatibility (Obaseki and Erhabor, 2023; Olumide et al., 2024; Bolarinwa and Kumapayi, 2023). The prevalence of high mismatch rates - particularly on seat height, seat depth, and armrest height - exposes HCWs to sustained postural stress that Kamijantono et al. (2024) and Garosi et al. (2025) associate directly with elevated MSD risk. Those armless chair types generally outperformed armchair types on most dimensions is an important practical finding, suggesting that targeted procurement of appropriately dimensioned armless seating may represent a cost-effective interim ergonomic improvement pending comprehensive furniture redesign.

Table 11. Match and Mismatch Percentages of Existing Armless Chairs in PHCFs of CM

Armless		Chair Type 3			Chair Type 4		
		Match (%)	Lower Mismatch (%)	Upper Mismatch (%)	Match (%)	Lower Mismatch (%)	Upper Mismatch (%)
PH vs SH	Male	66.7	33.3	0	33.3	29.6	37
	Female	52.3	17.4	30.2	36	9.3	54.7
HB vs SW	Male	55.6	22.2	22.2	48.1	3.7	48.1
	Female	45.3	50	4.7	54.7	23.3	22.1
BPL vs SD	Male	7.4	0	92.6	51.9	0	48.1
	Female	0	0	100	47.7	0	52.3
SSH vs BRH	Male	100	0	0	0	0	100
	Female	95.3	1.2	3.5	0	0	100

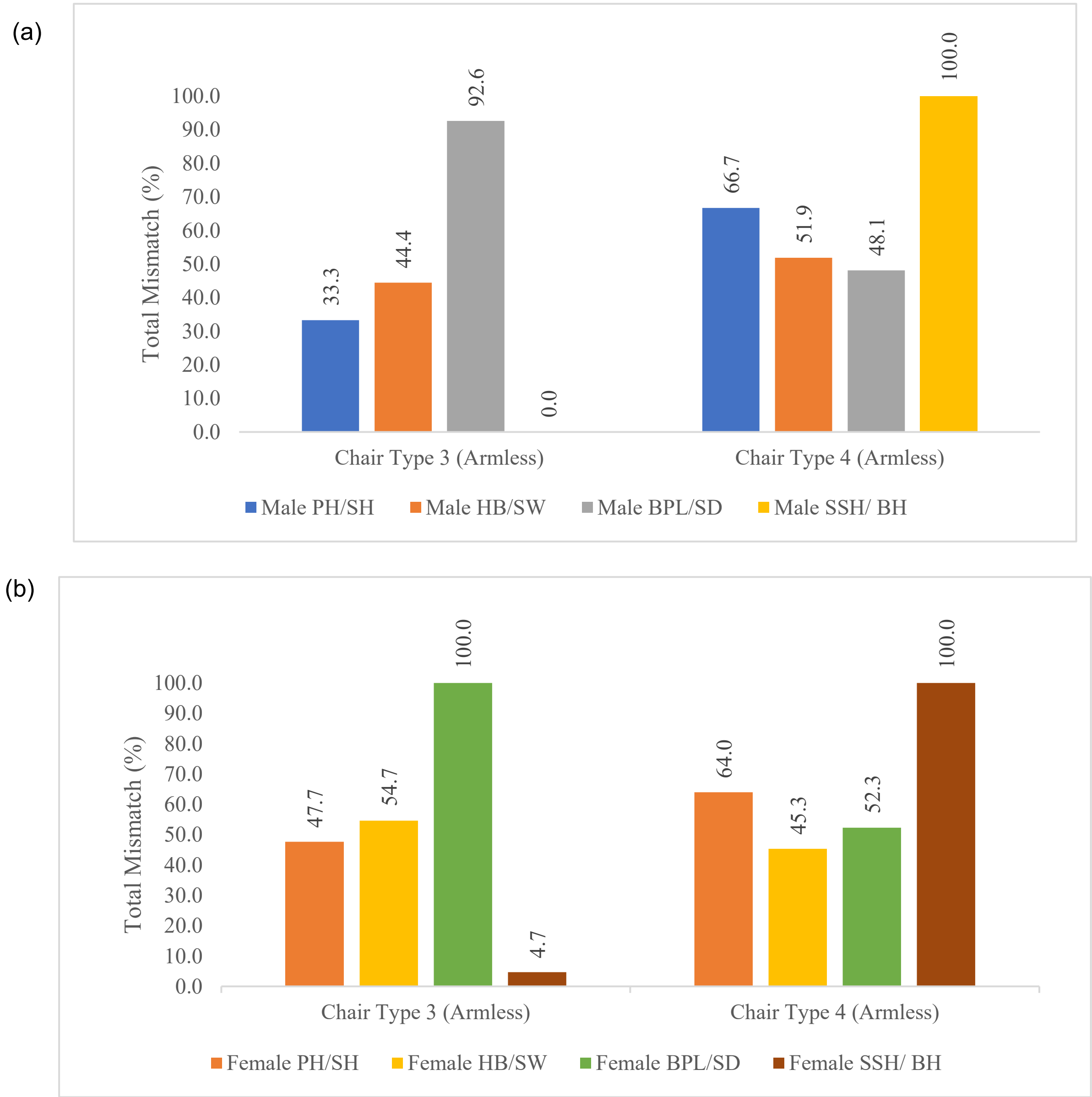

Figure 4a. Armless Chair Mismatch for Male HCWs in PHCFs of Calabar Metropolis, (b) Armless Chair Mismatch for Female HCWs in PHCFs of Calabar Metropolis

Table Height Mismatch

Table 12 and Figures 5a and 5b present the match and mismatch percentages for the fifteen table types assessed in the PHCFs. Overall, table height mismatch is pervasive, with total mismatch exceeding 70% for nearly all table types across both sexes. Upper mismatch - tables being too high relative to user elbow height and lower limb clearance - is the predominant direction of mismatch, reflecting the widespread use of tables designed without reference to the local user population.

Table Type 4, with a height of 930 mm, produced 100% total mismatch for both males and females, with all users experiencing upper mismatch, making it entirely unsuitable by ergonomic standards. Similarly, Table Type 12 (850 mm) produced 88.9% total mismatch in males and 98.8% in females. Tables at the higher end of the height range consistently produced near-total upper mismatch, as their heights exceed the ergonomic range computed from user elbow height and popliteal height dimensions.

Among the best-performing tables, Table Types 9 (670 mm) and 11 (710 mm) showed the most acceptable compatibility. Table Type 9 achieved 25.9% match in males and 51.2% in females, with predominantly lower mismatch - meaning that for the taller male subgroup, this table was somewhat too low, while it accommodated a larger proportion of females. Table Type 11 (710 mm) achieved 29.6% match in males and 51.2% in females, with a more balanced mismatch distribution. These results suggest that tables in the 670-760 mm height range offer the closest approximation to ergonomic compatibility for this population, particularly for female HCWs.

The predominance of upper mismatch across table types is particularly concerning. When table surfaces are too high, HCWs must elevate their shoulders and arms during writing and clinical tasks, imposing static muscular load on the trapezius and deltoid - a well-documented risk factor for neck and shoulder MSDs (Aiyegbusi et al., 2023; Isapka and Omorodion, 2019). This risk is compounded by the extended periods that PHC workers spend at workstations documented in prior studies (Oche and Adamu, 2013). Taifa and Desai (2017) similarly found dominant upper mismatch in institutional table heights in India when compared against local anthropometric data, reflecting a global tendency to adopt furniture dimensions from imported or non-contextualised standards.

The finding that female HCWs generally experienced lower total mismatch percentages on the better-performing tables (e.g., Table Types 9 and 11) compared to males can be attributed to the females' shorter stature and correspondingly lower elbow height sitting, which falls closer to the range accommodated by mid-range table heights. This sex-differentiated compatibility pattern corroborates findings by Oladapo et al. (2024) in Nigerian educational settings, where female students showed relatively higher furniture match rates than males when furniture dimensions were closer to the lower end of the ergonomic range.

Taken together, the table mismatch results confirm that standard procurement of mass-produced tables in Nigerian PHCFs creates a near-universal ergonomic hazard for HCWs. No single table type achieved match rates above 55% for either sex, indicating a fundamental misalignment between available furniture stock and the anthropometric profile of the workforce. This is consistent with the structural assessment of Nigerian PHCFs by Yisa et al. (2025), who identified poor infrastructure as a systemic barrier to effective primary healthcare delivery. The present findings add an ergonomic dimension to this infrastructural critique, demonstrating that furniture inadequacy is not merely an aesthetic or comfort issue but a measurable occupational health risk with well-documented consequences for MSD incidence and worker productivity (Kamijantono et al., 2024; Adiga, 2023; Garosi et al., 2025).

Table 12. Mismatch and Match Percentages of Existing Table heights in PHCF

	Match (%)	Lower Mismatch (%)	Upper Mismatch (%)	Total Mismatch (%)	Match (%)	Lower Mismatch (%)	Upper Mismatch (%)	Total Mismatch (%)	Match (%)	Lower Mismatch (%)	Upper Mismatch (%)	Total	Match (%)	Lower Mismatch (%)	Upper Mismatch (%)	Total Mismatch (%)
	Table Type 1				Table type 2				Table Type 3				Table Type 4			
Male	11.1	22.2	66.7	88.9	15	22.2	63	85.2	22.2	22.2	55.6	77.8	0	0	100	100
Female	16.3	0	83.7	83.7	20	0	80.2	80.2	25.6	0	74.4	74.4	0	0	100	100
	Table Type 5				Table Type 6				Table type 7				Table Type 8			
Male	14.8	22.2	63	85.2	11	7.4	81.5	88.9	11.1	7.4	81.5	88.9	11.1	7.4	81.5	88.9
Female	19.8	0	80.2	80.2	9.3	0	90.7	90.7	9.3	0	90.7	90.7	9.3	0	90.7	90.7
	Table Type 9				Table Type 10				Table Type 11				Table Type 12			
Male	25.9	70.4	3.7	74.1	7.4	14.8	77.8	92.6	29.6	40.7	29.6	70.4	11.1	0	88.9	88.9
Female	51.2	36	12.8	48.8	14	0	86	86	51.2	3.5	45.3	48.8	1.2	0	98.8	98.8
	Table Type 13				Table Type 14				Table Type 15							
Male	14.8	22.2	63	85.2	7.4	14.8	77.8	92.6	11.1	88.9	0	88.9				
Female	19.8	0	80.2	80.2	14	0	86	86	31.4	62.8	5.8	68.6				

(a)

(b)

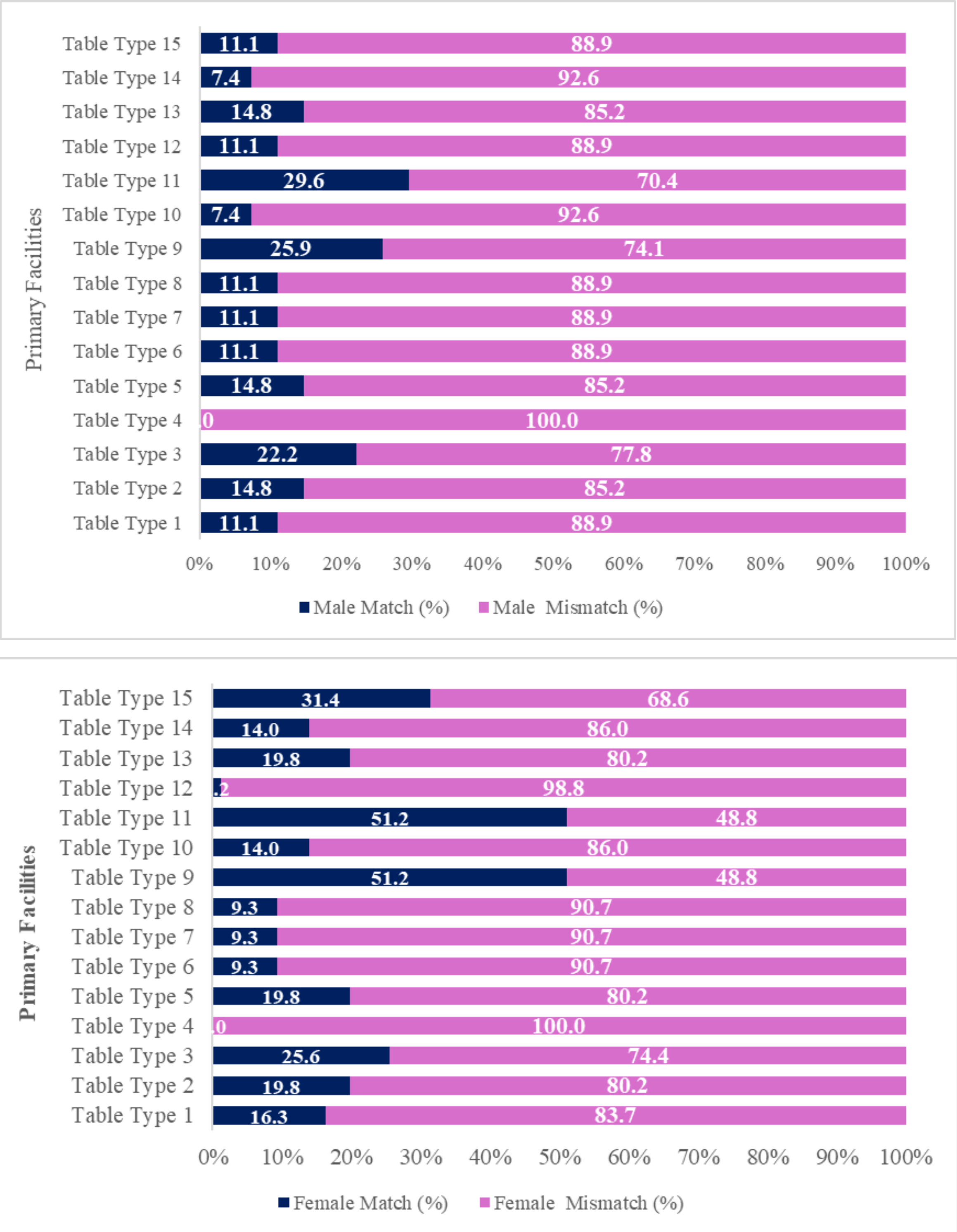

Figure 5a. Table Height Match and Mismatch for Male HCWs in PHCFs of Calabar Metropolis, **(b)** Table Hight Match and Mismatch for Female HCWs in PHCFs of Calabar Metropolis

Conclusion

This study provides the first sex-disaggregated anthropometric dataset for healthcare workers in primary healthcare facilities in Calabar Metropolis, Nigeria, and systematically evaluates the ergonomic compatibility of their workplace furniture. The findings reveal that the furniture currently in use is largely mismatched to the body dimensions of its users. The sex-disaggregated analysis further reveals that male and female HCWs face distinct patterns of mismatch, driven by differences in popliteal height, hip breadth, and elbow height sitting. This underscores the inadequacy of gender-neutral procurement approaches and calls for furniture standards that account for the morphological diversity of the Nigerian healthcare workforce. The anthropometric data generated by this study provide a practical foundation for the ergonomic redesign of chairs and tables suitable for primary care settings in this region. From a public health standpoint, the pervasive furniture-user mismatch documented here represents a tangible and preventable occupational hazard. Sustained exposure to ergonomically incompatible furniture is a well-established driver of musculoskeletal disorders, reduced productivity, and increased absenteeism among health workers — outcomes that further strain an already overburdened primary healthcare system. It is therefore recommended that furniture procurement agencies, healthcare administrators, and policymakers prioritise anthropometric compatibility in furniture selection and design for Nigerian PHCFs. Future studies should expand this assessment to other geopolitical zones of Nigeria to establish a national anthropometric database for primary healthcare workers that can inform standardised, context-appropriate furniture guidelines.

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During the preparation of this work the author(s) used ChatGPT (OpenAI) in order to improve the clarity and readability of the manuscript without altering the original content or scientific integrity. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Author contributions

Asibong A. Icha: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing - original draft, Writing - review & editing. Nureni A. Adewole: Conceptualization, Supervision, Writing - review & editing.

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