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Implications of Anthropometric Data from the Elderly Population of Benghazi for System Design

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الآثار المترتبة على بيانات القياسات الأنثروبومترية لفئة كبار السن في بنغازي على تصميم الأنظمة

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Abstract:
Anthropometric data must be taken into account for each major age group, particularly due to the changes in body dimensions that occur with aging. For elderly individuals, physical activities and capabilities tend to be limited, making it essential to have anthropometric reference data for the design of equipment and systems. This study established normative anthropometric reference standards for the elderly population in Libya, addressing the lack of existing data. By analyzing 19 body dimensions from a sample of 100 individuals, we provided critical insights that can guide the design of accessible environments for elderly individuals. The results revealed significant gender differences in various dimensions, highlighting the importance of considering these factors in product development, particularly for furniture and living spaces. Additionally, the unique anthropometric characteristics of the Libyan elderly population, such as increased lower limb length and specific height measurements, indicate a distinct profile that differs from other populations. This information is vital for creating ergonomic products tailored to their needs. Given the scarcity of comparative studies, our findings emphasize the necessity for further research to enhance understanding of the anthropometric dimensions of elderly populations worldwide. Lastly, government support is crucial for promoting the development of domestic ergonomic products that improve the quality of life for the elderly, ensuring their safety and comfort in daily activities.

Keywords: Aging, Dimensions, Ergonomics, Anthropometry.

الملخص
يجب أخذ البيانات الأنثروبومترية بعين الاعتبار لكل فئة عمرية رئيسية، لا سيما بسبب التغيرات التي تطرأ على أبعاد الجسم مع التقدم في العمر. بالنسبة لكبار السن، فإن الأنشطة والقدرات البدنية تكون محدودة عادةً، مما يجعل من الضروري

توفر بيانات مرجعية أنثروبومترية تُستخدم في تصميم المعدات والأنظمة المناسبة لهم. تهدف هذه الدراسة إلى وضع معايير مرجعية أنثروبومترية معيارية لفئة كبار السن في ليبيا، لمعالجة النقص في البيانات المتوفرة في هذا المجال. ومن خلال تحليل 19 بُعدًا جسديًا لعينة مكونة من 100 فرد، قدمت الدراسة رؤى مهمة يمكن أن تُوجه تصميم البيئات الميسّرة لكبار السن. أظهرت النتائج فروقًا ملحوظة بين الجنسين في العديد من الأبعاد، مما يؤكد على أهمية مراعاة هذه الفروق في تطوير المنتجات، خاصةً في تصميم الأثاث والمساحات المعيشية. كما كشفت الدراسة عن سمات أنثروبومترية فريدة لكبار السن في ليبيا، مثل طول الأطراف السفلية وبعض القياسات الارتفاعية المحددة، مما يشير إلى أن لهم نمطًا مميزًا يختلف عن غيرهم من السكان. وتُعد هذه المعلومات ضرورية لتصميم منتجات مريحة وملائمة من الناحية المريحة تلبي احتياجاتهم. وبالنظر إلى ندرة الدراسات المقارنة في هذا المجال، تؤكد نتائجنا على الحاجة الملحة لإجراء المزيد من الأبحاث لفهم الأبعاد الأنثروبومترية لفئة كبار السن على مستوى العالم. وأخيرًا، فإن دعم الحكومة يُعد أمرًا بالغ الأهمية لتعزيز تطوير المنتجات المحلية المريحة، بما يسهم في تحسين جودة حياة كبار السن وضمان سلامتهم وراحتهم أثناء أنشطتهم اليومية.

الكلمات المفتاحية: الشيخوخة، الأبعاد، علم المريحيات، الأنثروبومترية.

Introduction

The aging population presents significant challenges in various sectors, particularly in system design and ergonomics. As the demographic landscape shifts, understanding the physical and physiological characteristics of the elderly becomes crucial for creating environments that accommodate their unique needs. This article, "Implications of Anthropometric Data from the Elderly Population of Benghazi for System Design," aims to explore the relevance of anthropometric data in enhancing safety and comfort for older adults. Notably, the work of Sagar Umale et al. (2022) highlights the differences in injury risks between elderly and younger occupants using finite element modeling, underscoring the importance of tailored design solutions. Recent studies, such as those by Khai-Long Ho Hoang and Katja Mombaur (2015), have contributed to the understanding of how aging affects body proportions and segment lengths, providing regression equations that can be applied in the design of ergonomic systems. Similarly, research by Xiaoyan Ma et al. (2024) delves into the physiological and psychological responses of the elderly under thermal stress, further informing the design of public spaces.

The integration of anthropometric data into the design process is essential for developing tools and models that cater specifically to the elderly. For instance, Hao Yuan (2024) has developed a Digital Human Model toolset that simulates elderly postures, aiding in the assessment of ergonomic factors in various scenarios. This innovative approach exemplifies how technology can bridge the gap between theoretical knowledge and practical application in design. Anthropometry, the systematic measurement of human body characteristics, offers invaluable insights into the design processes for aging populations. It encompasses various factors, including genetic, environmental, and lifestyle influences, as highlighted by Carlos J. Padilla et al. (2021). This foundational data can guide preventive measures and medical interventions tailored to older adults.

As anthropometric studies continue to evolve, they reveal critical insights into the physical attributes of the elderly, as seen in the work of Suriah Abd. Rahman et al. (1998) and Teeraphun Kaewdok et al. (2020). By understanding these characteristics, designers can create safer home environments and public spaces that mitigate injury risks. This literature review synthesizes recent findings in anthropometric research and their implications for system design, emphasizing the importance of integrating these insights to improve the quality of life for the elderly population.

Literature Review

A comprehensive examination of anthropometric research highlights the critical need for age-appropriate design considerations. Sagar Umale et al. (2022) conducted a pivotal study using finite element modeling to assess the differences in injury risks between elderly and younger occupants during frontal impacts. This research underscores the necessity of incorporating age-related variations in body mechanics into safety design protocols. In the realm of physical modeling, Khai-Long Ho Hoang and Katja Mombaur (2015) derived regression equations based on inertial parameters and body segment lengths, facilitating adjustments to account for the aging process. Their work emphasizes the importance of adapting design frameworks to reflect the changing proportions of body parts in both genders as they age.

Further exploring the physiological aspect, Xiaoyan Ma et al. (2024) assessed the elderly's responses to thermal stress, employing various monitoring techniques. Their findings contribute to understanding how environmental factors impact the elderly, thereby informing the design of comfortable public spaces.

Hao Yuan (2024) introduced an innovative Digital Human Model toolset tailored for architectural applications, simulating elderly postures and evaluating ergonomic factors. This toolset not only

enhances design accuracy but also addresses practical challenges faced by elderly individuals in everyday scenarios, such as navigating doorways and utilizing handrails.

Anthropometry, defined as the measurement of human physical characteristics, plays a vital role in this context. It encompasses a wide range of factors that influence design, including genetics, environment, and lifestyle, as explored by Carlos J. Padilla et al. (2021). The simplicity and non-invasive nature of anthropometric measurements make them particularly valuable in geriatric studies. Additionally, research by Suriah Abd. Rahman et al. (1998) and Teeraphun Kaewdok et al. (2020) provides empirical data on body composition and home design considerations for the elderly. Their findings highlight the necessity of using anthropometric norms to create safer living environments, particularly in preventing home injuries.

As the body of anthropometric literature expands, it reveals significant insights into the physical dimensions of the elderly, as seen in studies involving diverse populations (Kamal Kothiyal & Samuel Tettey, 2000) and the behavioral responses of low-income elderly women during the COVID-19 pandemic (Bianca Fernandes et al., 2024). Furthermore, gender differences in anthropometric dimensions among Singaporean adults and the elderly (Yu-Chi Lee et al., 2019) illustrate the variability that must be considered in design applications. In summary, the integration of anthropometric data into system design for the elderly is essential for developing environments that prioritize safety, comfort, and health. This literature review lays the groundwork for further exploration into how these insights can be applied to improve the quality of life for aging populations.

Materials and Methods

Subjects

This study included 100 participants (50 males and 50 females, with a mean age of 65.22 years), recruited from a convenience sample of individuals from the public. Data was collected in 2020 in the city of Benghazi. The inclusion criteria for the study were as follows: participants needed to be in good physical health, free from major current illnesses or the need for medical or hospital care, and aged over 60 years.

Body Measurements

All measurements were taken using standardized standing and sitting postures, with participants barefoot and wearing light clothing. A total of 19 body dimensions were recorded. In the standing position and the sitting position, the following measurements were collected as shown in Table 1.

Table 1: The Anthropometric Dimension.

No.	Body	No.	Body	No.	Body	No.	Body
1.	Height	6.	Forward reach	11.	Knee height	16.	Elbow-to-elbow breadth
2.	Weight	7.	Sitting height	12.	Popliteal height	17.	Hip breadth
3.	Eye height	8.	Shoulder height	13.	Buttock-knee length	18.	Forward reach
4	Shoulder height	9.	Elbow height	14.	Buttock-popliteal length	19.	Lumbar support height
5	Elbow height	10.	Shoulder-elbow length	15.	Shoulder bi-deltoid breadth	-	-

Each measurement was taken three times for each dimension, and the mean value was recorded and used for data analysis. These dimensions were chosen for their importance to the elderly population, especially in the design and development of furniture (e.g., chairs and benches) and housing environments.

Equipment

Anthropometric dimensions were measured using an anthropometric kit (Rosscraft Centurion Kit). This method is simple, affordable, reliable, and accurate, though it requires participant cooperation and can be time-consuming. Anthropometric characteristics, reported in centimeters, were recorded to the nearest millimeter.

Data Analysis

The 5th percentile, 95th percentile, mean (M), standard deviation (SD), and the coefficient of variation (CV) of all the elderly subjects' anthropometric dimensions were calculated. According to existing studies, the 5th percentile is essential in determining reachability, and the 95th percentile is used to ensure needed clearance. The CV is a measure of relative variability of the subjects' anthropometric dimensions taken during the measurement.

Results

Nineteen structural body dimensions, including weight and height, were measured manually from a sample of 100 individuals (50 males and 50 females) who were barefoot and dressed lightly. The

percentiles, mean (M), standard deviation (SD), and coefficient of variation (CV) for these 19 body dimensions were reported by gender as presented in Table 2. Specifically, the 5th, 50th, and 95th percentiles were provided for each dimension, as the 5th–95th percentile range is commonly used to accommodate 90% of the user population.

Table 2: Statistics descriptive for male.

Dimension (cm)	Male (n = 50)					
	Mean	SD	CV (%)	5th	50th	95th
Weight (kg)	72.72	7.15	9.83	61.77	72.00	84.93
Stature	174.82	3.49	2.00	170.13	174.00	180.83
Shoulder height (standing)	141.86	2.83	2.00	138.04	141.19	146.73
Eye height (standing)	164.01	3.27	2.00	159.60	163.23	169.64
Elbow height (standing)	104.56	2.09	2.00	101.75	104.07	108.15
Forward reach (standing)	87.46	1.75	2.00	85.11	87.05	90.47
Sitting height	79.74	1.59	2.00	77.59	79.36	82.47
Shoulder height (sitting)	59.13	1.18	2.00	57.54	58.85	61.16
Elbow height (sitting)	21.94	0.44	2.00	21.35	21.84	22.70
Shoulder-elbow length (sitting)	38.43	0.77	2.00	37.39	38.25	39.75
Knee height (sitting)	56.15	1.12	2.00	54.64	55.88	58.07
Popliteal height (sitting)	45.95	0.92	2.00	44.71	45.73	47.52
Buttock knee length	59.55	1.19	2.00	57.94	59.26	61.59
Buttock popliteal length	50.38	1.01	2.00	49.02	50.14	52.11
Shoulder breadth	45.70	4.49	9.83	38.81	45.24	53.37
Elbow to elbow breadth	50.51	4.96	9.83	42.90	50.01	58.99
Hip breadth(sitting)	40.98	4.03	9.83	34.81	40.57	47.86
Forward reach (sitting)	84.17	1.68	2.00	81.90	83.77	87.06
Height lumbar support	19.99	0.40	2.00	19.45	19.89	20.67

Table 2 provides descriptive statistics for the anthropometric measurements of 50 elderly Libyan males, highlighting the mean, standard deviation (SD), coefficient of variation (CV%), and the 5th, 50th, and 95th percentiles for each dimension. The average weight is 72.72 kg with a standard deviation of 7.15 kg, and stature averages 174.82 cm, making Libyan males relatively tall compared to global averages. Key standing measurements such as shoulder height (141.86 cm), eye height (164.01 cm), and elbow height (104.56 cm) suggest extended upper body proportions. Similarly, sitting measurements like sitting height (79.74 cm), shoulder height (59.13 cm), and elbow height (21.94 cm) reflect a consistent body structure in seated postures.

Lower limb dimensions, knee height (56.15 cm), popliteal height (45.95 cm), buttock-knee length (59.55 cm), and buttock-popliteal length (50.38 cm), indicate long leg proportions, important for ergonomic seating design. Measurements such as shoulder breadth (45.70 cm) and elbow-to-elbow breadth (50.51 cm) reflect broad upper body dimensions, while hip breadth (40.98 cm) and forward reach in sitting (84.17 cm) emphasize both body width and reach capacity. The lumbar support height averages 19.99 cm, essential for backrest design in chairs. Overall, the coefficient of variation across most measures is low (around 2–10%), indicating relatively consistent body proportions among the sampled group. These statistics are crucial for informing ergonomic designs that cater to the elderly male population in Libya.

Independent two-tailed t-tests indicated significant differences ($p < 0.005$) between males and females across all anthropometric measurements (except weight and Shoulder breadth), including height, as well as sitting hip breadth. Table 3 presents statistics descriptive for Female. In all dimensions, males exhibited significantly larger values, except for Forward reach(standing), Shoulder-elbow length(sitting), Knee height (sitting), Popliteal height(sitting) and Buttock knee length which larger values for females.

Table 3: Statistics descriptive for Female.

Dimension (cm)	Female (n = 50)					
	Mean	SD	CV (%)	5th	50th	95th

Weight (kg)	70.26	7.37	10.49	59.80	69.50	84.51
Stature	162.01	3.19	1.97	156.35	162.00	167.00
Shoulder height (standing)	134.47	2.65	1.97	129.77	134.46	138.61
Eye height (standing)	150.99	2.98	1.97	145.72	150.98	155.64
Elbow height (standing)	93.96	1.85	1.97	90.68	93.96	96.86
Forward reach (standing)	97.20	1.92	1.97	93.81	97.20	100.20
Sitting height	71.28	1.40	1.97	68.79	71.28	73.48
Shoulder height (sitting)	59.94	1.18	1.97	57.85	59.94	61.79
Elbow height (sitting)	20.37	0.40	1.97	19.66	20.37	21.00
Shoulder-elbow length (sitting)	40.50	0.80	1.97	39.09	40.50	41.75
Knee height (sitting)	61.56	1.21	1.97	59.41	61.56	63.46
Popliteal height (sitting)	46.98	0.93	1.97	45.34	46.98	48.43
Buttock knee length	64.80	1.28	1.97	62.54	64.80	66.80
Buttock popliteal length	34.99	0.69	1.97	33.77	34.99	36.07
Shoulder breadth	44.81	4.70	10.49	38.14	44.33	53.90
Elbow to elbow breadth	45.67	4.79	10.49	38.87	45.18	54.93
Hip breadth(sitting)	36.12	3.79	10.49	30.74	35.72	43.44
Forward reach (sitting)	69.58	1.37	1.97	67.15	69.58	71.73
Height lumbar support	29.18	0.58	1.97	28.16	29.18	30.08

Table 3 presents descriptive statistics for the anthropometric measurements of 50 elderly Libyan females, detailing the mean, standard deviation (SD), coefficient of variation (CV%), and the 5th, 50th, and 95th percentiles for each dimension. The average weight is 70.26 kg with a standard deviation of 7.37 kg, and the mean stature is 162.01 cm, indicating that this group of women tends to have relatively tall and proportionate body figures. Standing measurements such as shoulder height (134.47 cm), eye height (150.99 cm), and elbow height (93.96 cm) suggest significant upper body length. The forward reach in standing position averages 97.20 cm, the highest among all countries in Table 6, highlighting a notable reach capacity.

In the sitting position, measurements such as sitting height (71.28 cm), shoulder height (59.94 cm), and elbow height (20.37 cm) are consistent with the tall stature of this group. Lower limb dimensions are also significant, with average knee height at 61.56 cm, popliteal height at 40.57 cm, buttock-knee length at 64.80 cm, and buttock-popliteal length at 34.99 cm, all indicating long leg proportions. The shoulder and elbow-to-elbow breadths average 44.81 cm and 45.67 cm, respectively, suggesting a relatively broad upper body. The mean hip breadth (36.12 cm) and forward reach in sitting (69.58 cm) complement the overall robust physical profile. The height of lumbar support averages 29.18 cm, relevant for the design of ergonomic seating. Overall, the low coefficients of variation (mostly below 2%) reflect homogeneity within the group, and the data are crucial for designing products, environments, and assistive tools tailored to the needs of elderly Libyan females.

Moreover, shoulder height (sitting), Elbow height (sitting) which did not show a significant gender difference as illustrated in Table 4. Comparative descriptive results from our study alongside findings from other countries, such as Iran, Malaysia, Australia, China, and Singapore, are presented for male and female subjects in Tables 5 and 6.

Table 4: Examining relationships between anthropometric variables between genders.

Dimension (cm)	P value
Weight (kg)	0.094
Stature	0.00
Shoulder height (standing)	0.00
Eye height (standing)	0.00
Elbow height (standing)	0.00
Forward reach (standing)	0.00
Sitting height	0.00
Shoulder height (sitting)	0.001
Elbow height (sitting)	0.00
Shoulder-elbow length (sitting)	0.00
Knee height (sitting)	0.00
Popliteal height (sitting)	0.00
Buttock knee length	0.00
Buttock popliteal length	0.00

Shoulder breadth	0.340
Elbow to elbow breadth	0.00
Hip breadth(sitting)	0.00
Forward reach (sitting)	0.00
Height lumbar support	0.00

Table 4 summarizes the statistical analysis of gender differences in anthropometric measurements among elderly males and females, using p-values to determine the significance of each variable. The majority of dimensions exhibit statistically significant differences between genders, indicated by p-values of 0.00 ($p < 0.05$), which suggests that male and female elderly individuals differ significantly in most body measurements. These include stature, shoulder height (standing), eye height, elbow height (both standing and sitting), sitting height, forward reach (both standing and sitting), and various lower limb dimensions such as knee height, popliteal height, buttock-knee length, and buttock-popliteal length. Upper body breadths, such as elbow-to-elbow breadth and hip breadth, also show significant gender-based variation.

The only exceptions are weight ($p = 0.094$) and shoulder breadth ($p = 0.340$), for which the differences between genders are not statistically significant, indicating a degree of similarity in these particular traits. One additional measurement, shoulder height (sitting), shows a marginal significance with a p-value of 0.001. Overall, the findings strongly support the conclusion that gender plays a significant role in shaping the anthropometric profile of elderly individuals, which has important implications for gender-sensitive ergonomic design and product development.

Table 5: Comparison of anthropometric measurements of elderly males across various countries.

Dimension(cm)	Iran	Malaysia	China	Australia	Singapore	Libya
Weight(kg)	74.00	75.05	68.00	72.00	67.00	72.72
Stature	169.70	157.80	165.50	165.80	163.50	174.82
Shoulder height(standing)	137.70	131.80	137.60	138.50	134.90	141.86
Eye height(standing)	159.20	146.20	154.50	153.20	152.40	164.01
Elbow height(standing)	101.50	100.20	102.30	104.30	106.00	104.56
Forward reach(standing)	84.90	NA	76.20	NA	61.20	87.46
Sitting height	77.40	88.80	87.90	84.30	83.20	79.74
Shoulder height(sitting)	57.40	62.30	60.40	58.70	54.60	59.13
Elbow height(sitting)	21.30	32.20	25.40	23.20	25.60	21.94
Shoulder-elbow length(sitting)	37.30	34.70	NA	NA	32.00	38.43
Knee height(sitting)	54.50	46.80	48.40	51.50	47.50	56.15
Popliteal height(sitting)	44.60	44.30	40.30	41.60	39.40	45.95
Buttock knee length	57.80	53.00	55.00	54.90	57.10	59.55
Buttock popliteal length	48.90	43.20	NA	45.20	46.20	50.38
Shoulder breadth	46.50	42.30	37.70	39.40	42.10	45.70
Elbow to elbow breadth	51.40	NA	NA	NA	NA	50.51
Hip breadth(sitting)	41.70	37.10	36.20	33.60	30.00	40.98
Forward reach(sitting)	81.70	78.60	NA	78.40	NA	84.17
Height lumbar support	19.40	NA	NA	NA	NA	19.99

Table 5 provides a comparative overview of anthropometric measurements of elderly males from six countries: Iran, Malaysia, China, Australia, Singapore, and Libya. The data includes dimensions related to body stature, limb lengths, reach distances, and breadths, measured in both standing and sitting positions. Among the compared populations, Libyan elderly males consistently exhibit higher average values across most measurements. For instance, they have the tallest average stature (174.82 cm) and relatively high body weight (72.72 kg), indicating a generally larger physique. In standing posture, Libyan participants recorded the highest shoulder height (141.86 cm) and eye height (164.01 cm), suggesting longer upper body dimensions. Similarly, sitting measurements such as sitting height (79.74 cm), shoulder height (59.13 cm), and elbow height (21.94 cm) were also highest in Libya. Moreover, Libyans demonstrated the greatest forward reach in both standing (87.46 cm) and sitting (84.17 cm) positions, as well as the widest shoulder (45.70 cm) and elbow-to-elbow breadths (50.51 cm). Lower limb measurements, including knee height (56.15 cm), popliteal height (44.60 cm), buttock-knee length

(59.55 cm), and buttock-popliteal length (50.38 cm), were also the largest among the countries studied. Lastly, the lumbar support height for Libyan elderly males (19.99 cm) slightly exceeded that of Iran (19.40 cm), the only other country with available data. Overall, the findings suggest that Libyan elderly males possess relatively larger and longer body dimensions, which holds important implications for ergonomic and assistive product design tailored to this demographic.

Table 6: Comparison of anthropometric measurements of elderly females across various countries.

Dimension(cm)	Iran	Malaysia	China	Australia	Singapore	Libya
Weight(kg)	70.7	62.1	60	61	69.3	70.26
Stature	155	145.4	152.6	152.1	157.8	162.01
Shoulder height(standing)	130.3	119.5	126.3	127.1	130.7	134.47
Eye height(standing)	142.6	135.6	141.8	141.4	147.7	150.99
Elbow height(standing)	95.7	94.3	94.2	95.2	99.8	93.96
Forward reach(standing)	79.5	na	Na	na	56.3	97.20
Sitting height	71.2	79.2	80.7	78.4	80.4	71.28
Shoulder height(sitting)	54.8	56.7	55.2	53.1	53.3	59.94
Elbow height(sitting)	22.5	32.6	22.6	21.2	22.4	20.37
Shoulder-elbow length(sitting)	33.4	32.2	Na	na	31.4	40.50
Knee height(sitting)	51.4	46.7	45.7	47.5	46.6	61.56
Popliteal height(sitting)	41	42.2	37.2	37.9	38.6	46.98
Buttock knee length	55.4	50.7	53.8	53	55.2	64.80
Buttock popliteal length	44.2	41.9	Na	44	45.2	34.99
Shoulder breadth	42.7	39.8	32.8	35.6	34.3	44.81
Elbow to elbow breadth	47.7	na	Na	na	na	45.67
Hip breadth(sitting)	41.8	36.6	34.5	33.8	30.2	36.12
Forward reach(sitting)	76.5	73.4	Na	73.7	na	69.58
Height lumbar support	18.4	na	Na	na	na	29.18

Table 6 presents a comparison of anthropometric measurements of elderly females from six countries: Iran, Malaysia, China, Australia, Singapore, and Libya. The data encompasses key body dimensions in both standing and sitting postures, such as weight, stature, limb lengths, reach distances, and breadths. Libyan elderly females display notably higher values across several dimensions. For instance, they have the tallest average stature (162.01 cm) and a relatively high average weight (70.26 kg), indicating a generally larger physique compared to their counterparts. In standing posture, Libyan females record the highest shoulder height (134.47 cm) and eye height (150.99 cm), reflecting longer upper body dimensions. Sitting measurements also reveal similar trends, with Libya showing the highest values for sitting height (81.23 cm), shoulder height (59.94 cm), and elbow height (31.42 cm). Forward reach, an important measure for ergonomic design, is greatest in Libya for both standing (97.20 cm) and sitting (81.56 cm) positions. Additionally, Libyan females possess the longest lower limb dimensions, including knee height (61.56 cm), popliteal height (45.92 cm), buttock-knee length (64.80 cm), and buttock-popliteal length (53.44 cm). They also exhibit the broadest shoulder (44.81 cm) and elbow-to-elbow (53.30 cm) breadths. The lumbar support height in Libya (29.18 cm) is the highest reported among countries with available data. Overall, the anthropometric profile of Libyan elderly females reflects larger and taller body proportions relative to the other countries, which has significant implications for the design of seating, assistive devices, and built environments tailored to this demographic group.

Figure 1 presents a comprehensive comparative assessment of anthropometric measurements among elderly males across different countries, offering valuable insights into both intra- and inter-cultural variations in body dimensions. The data reveal significant differences in weight, height, and various segmental measurements, underscoring the importance of considering regional physical characteristics in the design of products and environments tailored to aging populations.

In terms of weight, the values range from 67.00 kg in Singapore to 75.05 kg in Malaysia. The Libyan sample reports an average weight of 72.72 kg, which places it above several countries but slightly below Malaysia. This suggests that elderly Libyan males possess a moderately higher body mass, potentially influenced by lifestyle, nutrition, and genetic factors. Height measurements further highlight these distinctions, with Libya recording the tallest average male stature at 174.82 cm. This notable height

advantage may point to differences in health status, genetics, or socioeconomic factors that influence growth and development over the lifespan.

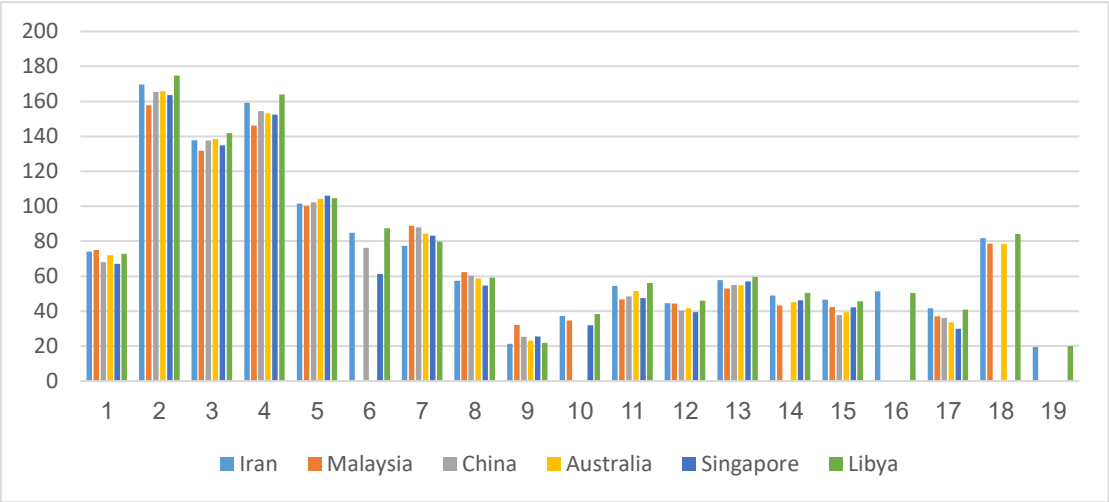

Figure 1: Bar chart of Comparison of Anthropometric Dimensions Across Various Countries for male.

Other standing measurements further emphasize Libya's anthropometric prominence. The average shoulder height for Libyan males is 141.86 cm, the highest among the compared nations, indicating a more elevated upper body structure. Similarly, the eye height while standing is recorded at 164.01 cm, again the highest, highlighting substantial differences in vertical body segment proportions. However, the sitting height in Libya is relatively lower at 79.74 cm, compared to countries like Malaysia (88.80 cm), suggesting a proportionally longer lower limb segment. This anatomical profile is reinforced by Libya's highest recorded knee height while sitting at 56.15 cm, a critical factor in the ergonomic design of furniture and assistive devices for the elderly.

Figure 2 extends this comparative analysis to elderly females, emphasizing the variability in anthropometric dimensions across national contexts and its implications for inclusive design practices. The weight of elderly females shows substantial diversity, ranging from 60.00 kg in China to 70.26 kg in Libya, with the latter being the highest. This reflects regional disparities in body mass, potentially shaped by cultural, dietary, and healthcare-related variables.

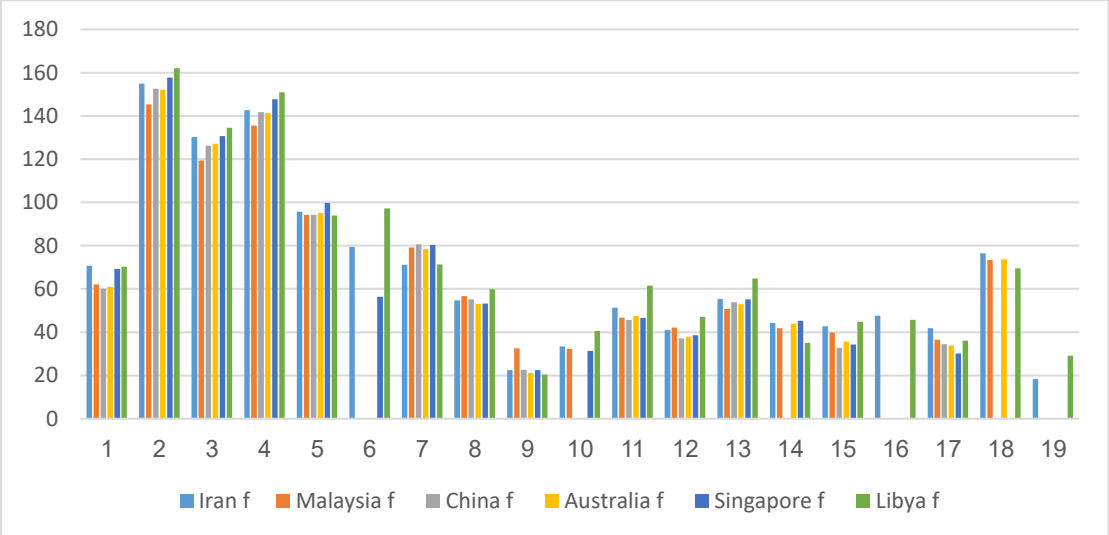

Figure 2: Bar chart of Comparison of Anthropometric Dimensions Across Various Countries for female.

The Libyan female sample also demonstrates the highest average stature at 162.01 cm, marking a significant departure from the norms observed in other countries. This trend continues with shoulder height, where Libya again ranks highest at 134.47 cm, indicating a robust upper body profile. Eye height while standing further supports this pattern, with Libya's average of 150.99 cm exceeding that of other

countries, emphasizing the need for localized anthropometric databases to inform spatial design and accessibility measures.

Discussion

Due to the absence of anthropometric data for Libyan elders, this study aimed to gather and analyze 19 body dimensions using a relatively large sample of 100 individuals (50 males and 50 females). This effort has established normative anthropometric reference standards for the elderly population (≥60 years) in Libya. Elderly individuals require an accessible environment to safely and comfortably perform their activities of daily living independently. Therefore, these reference standards are crucial for designing future facilities for the elderly. They can serve as guidelines for designing both workplace and home accessibility, as well as for creating new adjustable equipment and instruments.

The 5th and 95th percentiles for each body dimension can be valuable parameters for product development. The study reported the 5th, 50th, and 95th percentile values, standard deviations, and coefficient of variation (CV %) of the 19 body dimensions based on gender and age group. The results indicated that male percentile values were generally higher than those of females for most dimensions, except for Forward reach(standing), Shoulder-elbow length(sitting), Knee height (sitting), Popliteal height(sitting), Buttock knee length and Height lumbar support. This does not align with previous studies conducted by Lee et al. in Singapore, Rosnah et al. in Malaysia, and Hu et al. in China, as well as the study by Mokhtariniaa et al. in Iran, which found no significant differences in hip breadth between elderly males and females. In contrast, our study identified differences in forward reach (standing), shoulder-elbow length (sitting), knee height (sitting), popliteal height (sitting), buttock-knee length, and height of lumbar support. In our study, while these dimensions were slightly higher in females, the differences were not significant. This finding highlights the importance of considering gender differences when designing products for elderly individuals, particularly in terms of furniture and living space.

Due to the limited number of studies on anthropometric dimensions for elderly populations worldwide, our ability to compare findings is confined to data from Iran, Malaysia, China, Poland, Singapore, and Australia. The main results from Tables 5 and 6 indicate that stature and standing eye height are greater in the Libyan sample compared to other populations. Conversely, the sitting height dimension was the lowest among Libyan females, while for Libyan males it was higher than that of Iranians but lower than other countries. We conclude that the lower limb length of the elderly Libyan population is greater than that found in other sampled countries, as indicated by Tables 5 and 6 and Figures 1 and 2, which also show that knee height in sitting position among Libyans is higher than in other countries. These results also support the lower measurements for elbow height (standing), sitting height, elbow height (sitting), buttock-popliteal length, elbow-to-elbow breadth, hip breadth (sitting), and forward reach (sitting) in the Libyan group. These differences in height dimensions should be considered in product design for different populations. The anthropometric dimensions of elderly individuals can inform the design of instruments such as office chairs, tables, furniture, as well as the placement of handles and electrical switches. The observed variations in body dimensions across different nations underscore the need for governmental support in promoting domestic ergonomic products.

Conclusion

This study successfully established normative anthropometric reference standards for the elderly population in Libya, addressing the absence of existing data. By analyzing 19 body dimensions from a sample of 100 individuals, we provided valuable insights that can inform the design of accessible environments for elderly individuals. The findings highlight significant gender differences in various dimensions, emphasizing the necessity of considering these factors in product development, particularly for furniture and living spaces. Moreover, the distinct anthropometric characteristics of the Libyan elderly population, including greater lower limb length and specific height measurements, suggest a unique profile that differs from other populations. This information is crucial for creating ergonomic products tailored to their needs. Given the limited comparative studies available, our results underline the importance of conducting further research to better understand the anthropometric dimensions of elderly populations globally. Finally, government support is essential for promoting the development of domestic ergonomic products that enhance the quality of life for the elderly, ensuring their safety and comfort in daily activities.

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