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Comparison of Anthropometric Dimensions in Healthy and Disabled Male Individuals in Benghazi Libya

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ABSTRACT
This project aims to gather anthropometric data from wheelchair users in Benghazi and compare it with measurements from healthy individuals. The data collection took place at the Center for Persons with Disabilities in Benghazi, focusing on nine anthropometric dimensions relevant to wheelchair and seat design. The study compared these dimensions between healthy and disabled individuals aged 20 to 29. Data analysis was performed using Minitab 17.1 and descriptive statistics in Microsoft Excel. A T-test was used to assess differences between the two groups. The findings revealed significant differences in three out of nine dimensions, with P-values less than 0.05. These differences were attributed to variations in skeletal structure, relaxed back muscles, and difficulties in maintaining an upright posture. Comparisons with studies from Poland, America, and Iran showed that the body dimensions of wheelchair users in Benghazi differ from those in the other three countries. Additionally, the results highlighted significant differences in anthropometric dimensions between healthy and disabled individuals, with the most notable differences observed in height and reach.
Key words: *Ergonomics, Anthropometry, Disabled People*

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I. INTRODUCTION

Ergonomics is the scientific study focused on understanding the interaction between humans and various components within systems. It applies theories, principles, and methods to design systems that facilitate healthy and effective performance. Anthropometry is integral to ergonomics (1). Anthropometry, which involves precise body measurements to distinguish between individuals and groups, serves as a valuable tool in the design process. It encompasses measurements of body dimensions, volumes, centers of gravity, inertial properties, mass, and body segments (2). Experts in ergonomics utilize anthropometric data to determine appropriate dimensions for living spaces, work environments, and tools across rehabilitation, military, industrial, educational, and sports settings (3, 4). Individuals with physical disabilities, whether due to chronic illness, aging, or other factors, often spend significant time in seated positions or using wheelchairs (5, 6). Approximately 2.6% (6.8 million) of the US population use assistive devices, with nearly a quarter of these individuals relying on manual wheelchairs for mobility (7).

The effectiveness of this tool for disabled individuals largely hinges on its design (8). In other words, when equipment is designed based on accurate anthropometric data, it can empower disabled individuals, lower healthcare costs, and enable them to participate in society similarly to those without disabilities (9). However, the general lack of up-to-date anthropometric data for wheelchair users hampers designers' ability to create environments and products that are both effective and safe for this diverse group. Studies have indicated that the anthropometric data currently used by experts and designers is over 30 years old. During this time, changes in population demographics and physical characteristics have been substantial (10).

Thus, while anthropometric data is available for healthy individuals, it is scarce for those with disabilities who use wheelchairs (11). Additionally, some designers have created equipment for disabled individuals based on the characteristics of healthy people (12). However, due to the differing capabilities of disabled individuals, designing their equipment using data from healthy individuals is not practical (13). Research in the field of anthropometry for wheelchair users includes studies such as those by Paquet and Feathers (2004), which focused on 120 male wheelchair users to determine static anthropometric dimensions (14), and the study, which aimed to gather anthropometric data for adult wheelchair users in Mexico. This study involved 108 disabled individuals

(56 males and 52 females) who used wheelchairs and had sufficiently functional upper extremities for professional tasks (1). Another study involved designing functional clothing tailored for wheelchair users (7).

Despite these insights, gaps remain in understanding the full scope of anthropometric differences between healthy and disabled male individuals, especially in diverse cultural and socioeconomic contexts. The study in Iran that found notable differences in anthropometric measurements between healthy and disabled individuals, with the most significant variations observed in height and access limitations (15). This study aims to contribute to this body of knowledge by conducting a comparative analysis of anthropometric dimensions among male individuals in Benghazi, Libya, thereby advancing our understanding of health disparities and informing tailored healthcare strategies.

In summary, the literature underscores the importance of examining anthropometric dimensions in both healthy and disabled male populations to elucidate the impacts of disabilities on physical health and to promote equitable healthcare practices globally.

II. METHODS

This analytic-descriptive study was performed during the year 2021 in Benghazi City. The sample population consisted of 20 disabled and healthy individuals, including 10 healthy and 10 disabled males. It is important to note that anthropometric data is influenced by factors, such as age and occupation, type of disability, and degree of disability (1). To prevent aging-related effects, this study focused on samples aged 20 to 29 years. Disabled individuals were manual wheelchair paraplegic users with their upper extremities sufficiently efficient to perform professional activities, while healthy participants were official staff. The simple probability sampling method was used. In this research, 9 anthropometric dimensions that are applied in designing wheelchairs and seats were measured. Figure 1 shows static measurements, including height, length, and width. After obtaining contact with official staff and wheelchair users, individuals were held in standard posture and dimensions were measured based on the studies (11, 13-16). Measurements were performed while males loose clothing and were without shoes; after body physical measurements some modifications were applied on their shoes (2.5 cm added heel). The standard posture of disabled users on wheelchair and official staff on adjustable chair is such that individuals sit on a horizontal plane and enhance their body as much as possible, look straight forward, free their shoulders, hang their elbows vertically, and their thighs and wrists are in the horizontal position while the calf is in a vertical position. To maintain this position for individuals with disabilities, an adjustable chair was used to support their thighs and calf. In this study, tools such as 1: adjustable chair, 2: Caliper in large and small sizes, 3: Tape meter and metal meter (1 mm, accuracy), 4: scaled board of anthropometry were used for body measurements. Table 1 demonstrates measured dimensions in standard physical statements of anthropometry in sitting postures.

Table 1: Dimension of Anthropometry based on the method of standard measurements; sitting posture

	Body Dimension Definition	**Body Dimension Definition**
A	Sitting Height	Floor to Top of the Head
B	Eye Height	Floor to centre of the Eye
C	Shoulder Height	Floor to Acromion
D	Popliteal Length	
E	Popliteal Height	Popliteal Cavity- Floor
F	Hip-knee length	Posterior side of the Buttocks-articular Line of the Popliteal Cavity
G	Hip Breadth	Lateral Aspect of the Hip
H	Shoulder Breadth	Lateral Aspect of the Deltoids at the Shoulder Level
I	Arm Reach Forword	Protraction of the Shoulder

III. RESULTS

The data collected was analyzed using the statistical program Minitab 17.1. Descriptive statistics (using Microsoft Excel) as mean, and standard deviation was calculated for each dimension. A T-test was performed to determine the dimensional differences between the healthy and the disabled. The results of this test were used to develop the wheelchair as described later.

3.1 Descriptive Analysis

Descriptive statistics for healthy and disabled males are shown in Table 2. In this study, an average of 9 (9) of the dimensions of a healthy body were obtained for people with disabilities from 20 to 29 years old in a sitting position in a wheelchair and comfortable chairs (Table 1 and Fig. 1). The project was showed that the average sitting height was 86.73 ± 4.527 cm among disabled and 84.53 ± 6.896 cm among healthy. This result showed a higher average rate of sitting height among disabilities compared to cases with healthy participants.

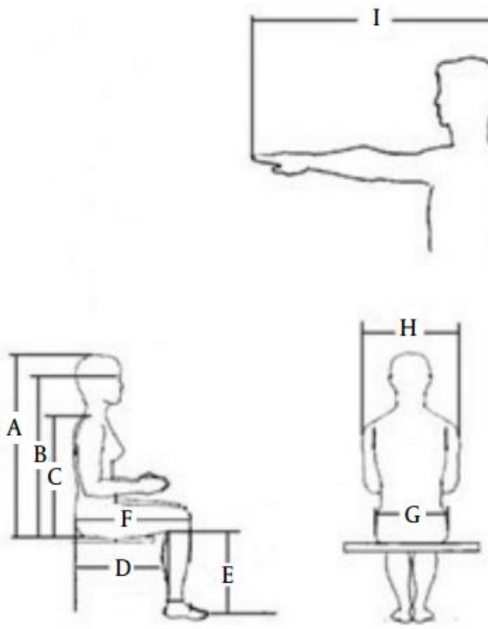

Figure 1: Dimension of Anthropometry based on the method of standard measurements; sitting posture

Table 2: Anthropometry Dimension among Healthy and Disabled Males (cm)

Variable	Group	Healthy males N=15		Disabled males N=15	
	Dimension	Mean	SD	Mean	SD
A	Sitting height	84.53	6.896	86.73	4.527
B	Eye height	74.07	6.861	76.73	4.096
C	Shoulder height	55.6	6.522	60.53	3.944
D	Arm reach forward	45.6	2.694	56.4	9.53
E	Shoulder breadth	48.87	3.357	49.4	4.388
F	Hip breadth	52.93	5.021	63	6.845
G	Popliteal heights	36.53	3.021	35.53	2.9
H	Popliteal Length	42.8	3.529	45.8	5.71
I	Knee-hip Length	77.6	5.73	82.33	7.257

3.2 A Comparison of Anthropometry Dimensions among Healthy and Disabled Mal

In this study, nine (9) body dimensions of healthy and disabled people were compared. Comparison between healthy and disabled males' subjects showed that three dimensions out of nine had a significant difference between them, $p < 0.05$ (as shown in Table 3).

Table 3: Comparison of Anthropometry Dimensions among Healthy and Disabled Males in Sitting Position with t Test

Variables	Body Dimensions	Healthy Male N=15	Disabled Male N=15	P Value
A	Sitting height	84.53	86.73	0.159
B	Eye height	74.07	76.73	0.124
C	Shoulder height	55.6	60.53	0.011
D	Arm reach forward	45.6	56.4	0.000
E	Shoulder breadth	48.87	49.4	0.372
F	Hip breadth	52.93	63	0.000
G	Popliteal heights	36.53	35.53	0.205
H	Popliteal Length	42.8	45.8	0.072
I	Knee-hip Length	77.6	82.33	0.052

3.3 A comparison of the mean n Anthropometrics Data Among Four Countries (Libyan, Iranian, America and Poland)

In this study, the mean of 4 body dimensions of Libyan (Benghazian) wheelchair users was compared with three studies conducted in Iranian, America and Poland (Table 4). The results of this study, in comparison with three studies in Iranian, America and Poland, showed that the hip and Shoulder dimension of Libyan (Benghazian) wheelchair users were greater (Table 4). However, the popliteal height in the three countries was greater compared to Libyan (Benghazian) wheelchair users. While, sitting height of Libyan (Benghazian) and Iranian wheelchair users were greater compared with Poland and American wheelchair users.

Table 4: Mean Anthropometrics Data Among Four Countries

Body Dimension	Libya wheelchair User		Iranian wheelchair User		Poland wheelchair User		American wheelchair User	
Percentile	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Sitting height	86.73	4.527	78.4	6.75	86.44	5.85	79.6	6
Shoulder breadth	49.4	4.388	36.39	3.95	32.94	8.5	26.3	3.9
Hip breadth	63	6.845	44.6	4	39	2.38	53.4	5.2
Popliteal height	35.53	2.9	48.14	4.02	54.88	5.24	52.2	6.8

IV. DISCUSSION

A comparison of body dimensions between disabled and healthy individuals showed that shoulder height, forward arm reach, and hip breadth were notably larger in healthy males compared to those with disabilities. However, there were no significant differences in sitting height, eye height, shoulder breadth, popliteal height, popliteal length, and front knee-hip length between the two groups.

This study underscores the variations in body dimensions between disabled and healthy individuals. Other research has suggested that issues with joint function, ligaments, and the neural-muscle system in disabled people lead to body deformities and alterations in body size [17, 18, 19], which contrasts with our findings.

In contrast to other studies [17, 2], which propose that shorter sitting height and limited reach in disabled individuals are due to skeletal deformations, relaxed back muscles, and difficulties in maintaining a straight posture.

In addition to factoring in backrest height and reach distances for adjusting barriers, controls, and nearby equipment (1, 3, 9, 8, 18), differences in body dimensions between healthy and disabled individuals result in varying workspace sizes. Neglecting these differences in workspace design may lead to mismatches with individual needs, causing dissatisfaction, stress, and musculoskeletal issues for disabled individuals (20, 21), who have more significant physical requirements than healthy individuals (10).

our study found that Benghazi wheelchair users have different body dimensions compared to those in Iran, America, and Poland. Specifically, the shoulder and buttock widths in Benghazi users were larger than in these other populations. These dimensions are important for designing back rests and wheelchair widths [17, 2, 8]. Nonetheless, sitting height and sitting popliteal height in Benghazi wheelchair users were lower than in the other populations. Accurate sitting position dimensions are essential for designing office workstations, desks, chairs, and wheelchairs, and these measurements are critical for determining appropriate chair heights and seat lengths [15, 22].

V. CONCLUSION

This paper summarized the structural anthropometric dimensions of 15 male wheelchair users in comparison with 15 male office workers. Results of this study showed that the body dimensions of disabled people differ from healthy people, which is because of deformation of skeletal systems, looseness of back muscles, and difficulty in keeping the body in a straight position. Due to the study's constraints, including the lack of advanced tools for measuring anthropometric dimensions, such as digital and 3D measurement technologies, there is a need for ongoing efforts to enhance our understanding of the anthropometry of wheelchair users. Emerging methods for measurement and data presentation are expected to provide new and effective ways to apply anthropometry in designing for this critical population segment.

Additionally, this paper outlines nine key anthropometric measures for wheelchair users, which are crucial for designing workstations across various industries. Based on the results of the comparisons with other studies on populations of Poland and America and Iran, it could be concluded that body dimension of Benghazi city wheelchair users is different from the 3 mentioned countries; the results also indicate significant differences among healthy and disabled people in anthropometric dimensions and the highest difference was found in the height dimension and access limits.

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