Volume 1.0

DESIGN RESOURCES

Analysis of Seat Height for Wheeled Mobility Devices

Center For Inclusive Design and Environmental Access

Analysis of Seat Height for Wheeled Mobility Devices

Clive D'Souza and Edward Steinfeld

IDeA Center
School of Architecture and Planning
University of Buffalo, SUNY

July 19, 2011

Summary: The following report provides a brief analysis of occupied seat heights for wheeled mobility device users in the U.S. The data are based on findings from the Anthropometry of Wheeled Mobility (AWM) Project, and comprises of detailed measurements collected from 495 users of manual wheelchairs, power wheelchairs and scooters. Our analyses show that occupied seat height varies considerably across the three categories of mobility devices, as well as across gender. In general, seat heights among manual wheelchair users were lowest, followed by power wheelchairs, with scooter users having the tallest seat heights. Within each device group, seat heights for males were typically greater than females. Power wheelchair users also had the largest range of values for seat height, ranging from 16.2 inches to 28.9 inches.

Keeping the transfer surface at the same height as wheeled mobility seat height reduces the effort needed to transfer since the individual does not have to lift their body weight to make up the difference between the two surfaces, in one direction or the other. Equivalent heights provide greater safety and convenience. Given the large diversity within the wheeled mobility population, a considerable range of adjustability is needed to design seating and transfer surfaces that provide equivalent heights for all users. We recommend that this range be between 17 inches minimum to 25 inches maximum. A minimum height above 17 inches would exclude about 6% of the manual wheelchair users in our sample. A maximum height of 25 inches would exclude about 8 percent of the power chair users and 9 percent of the scooter users. However, scooter users with high seat heights have adjustable seat heights so that they could lower their seats when necessary. Also, to use a scooter, they should have the ability to stand up and pivot when transferring. Lowering the 25 inch maximum dimension would exclude a much larger number of power wheelchair and scooter users.

Definition: Occupied seat height was measured as the vertical height from the floor to the lowest point on the seating surface of the mobility device with the occupant seated in the device. Measurements were taken by digitizing specific locations on the occupant and device using an electromechanical probe (FaroArm Inc.).

Study Sample: Currently, scooter users are underrepresented in our sample. There are only 30 scooter users out of the 495 wheeled mobility users measured in this study. But, the results for scooter users generally fall within the ranges for manual and power wheelchair users.

Results

The analysis is divided into three sections. First, we present summary statistics to describe key trends and differences in occupied seat height across different device types and gender. Second, we present a percentile analyses to identify a range of adjustability to accommodate a desired proportion of the wheeled mobility user population. Last, we present examples of some of the extreme cases and outliers that may likely be excluded or may not be accommodated based on the recommendations made.

A. Summary Statistics

Our analysis found that occupied seat height varied considerably across device type and gender. In general, seat heights among manual wheelchair users were lowest, followed by power wheelchairs, with scooter users having the tallest seat heights. Within each device group, seat heights for males were typically greater than females, with a mean difference of approximately 1 inch.

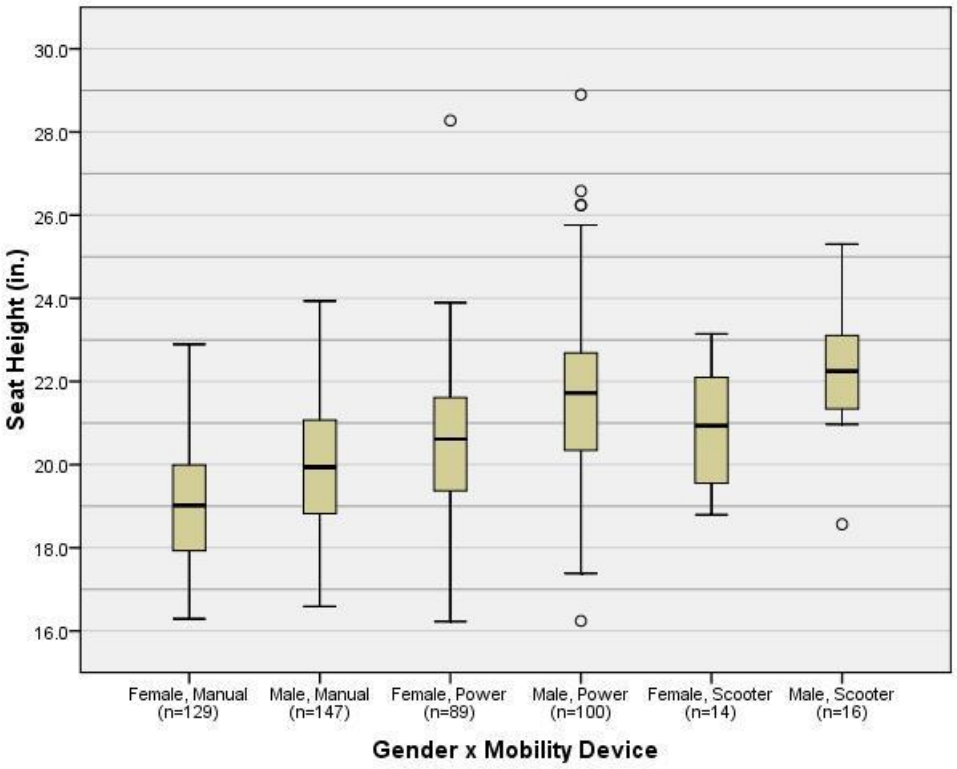

Figure 1: Box-plot showing the key statistics for occupied seat height stratified by gender and mobility device type. The horizontal line splitting the box depicts the median, the box length represents the inter-quartile (25^{th} – 75^{th} percentile) range, and the whiskers represent the minimum and maximum values. Extreme values and outliers are shown as dots.

	Sample size	Median (in.)	Mean (in.)	SD (in.)	Min (in.)	Max (in.)
Manual Wheelchair users						
Female	129	19.0	19.1	1.45	16.3	22.9
Male	147	19.9	19.9	1.52	16.6	23.9
Power Wheelchair Users						
Female	89	20.6	20.6	1.7	16.2	28.3
Male	100	21.7	21.8	2.03	16.2	28.9
Scooter Users						
Female	14	20.9	20.9	1.43	18.8	23.1
Male	16	22.2	22.3	1.57	18.6	25.3

Table 1 Data used to produce the box plot in Fig. 1

B. Percentile Analysis

This section presents a percentile analyses to help identify the range of adjustability to accommodate a desired proportion of the wheeled mobility user population. The term 'percentile' reflects the percent of the sample having an occupied seat height equal to or less than a particular dimension value. For example, traditional ergonomics research often uses the 5^{th} to 95^{th} percentile values to identify a reasonable range of adjustability. However, basing design criteria for accessibility using this thumb-rule is not recommended without having some idea of the characteristics and functional abilities of the persons that fall outside this range and might likely be excluded. For example, these might be individuals with the most severe debilitating or severe medical conditions who might need the greatest assistance during a transfer task.

Table2: The following table shows seat height inches, and the corresponding percentile (green shaded shows the recommended range of adjustment)

Seat Height	Percent of sample with seat heights equal to or less selected seat heights (First Column)					
	Manual, Female	Manual, Male	Power, Female	Power, Male	Scooter, Female	Scooter, Male
16 in.						
17 in.	7	3	2	2		
18 in.	29	13	6	3		
19 in.	51	30	19	6	13	
20 in.	75	53	36	19	33	
21 in.	90	74	61	36	53	12
22 in.	96	93	81	58	73	35
23 in.		97	95	79	93	71
24 in.			98	88		84
25 in.				92		91
26 in.				96		

Table 2 demonstrates that setting the minimum dimension lower than 17 in. would not result in appreciable gains in usability overall. Increasing the minimum above 17 in. even two inches, however, would exclude a significant proportion of the manual wheelchair group, in particular, over 30% of the females in the sample. Increasing the maximum limit above 25 in. would not significantly increase the proportion of our study sample accommodated. Lowering the upper limit to 19 in., however, would exclude a large majority of the sample.

Figure 2 shows The spread between the six lines provide some indication of the how the six different sub-groups of users differ from each other. For a given seat height on the horizontal axis the corresponding percentile values across the six different sub-groups can be identified from the vertical axis.

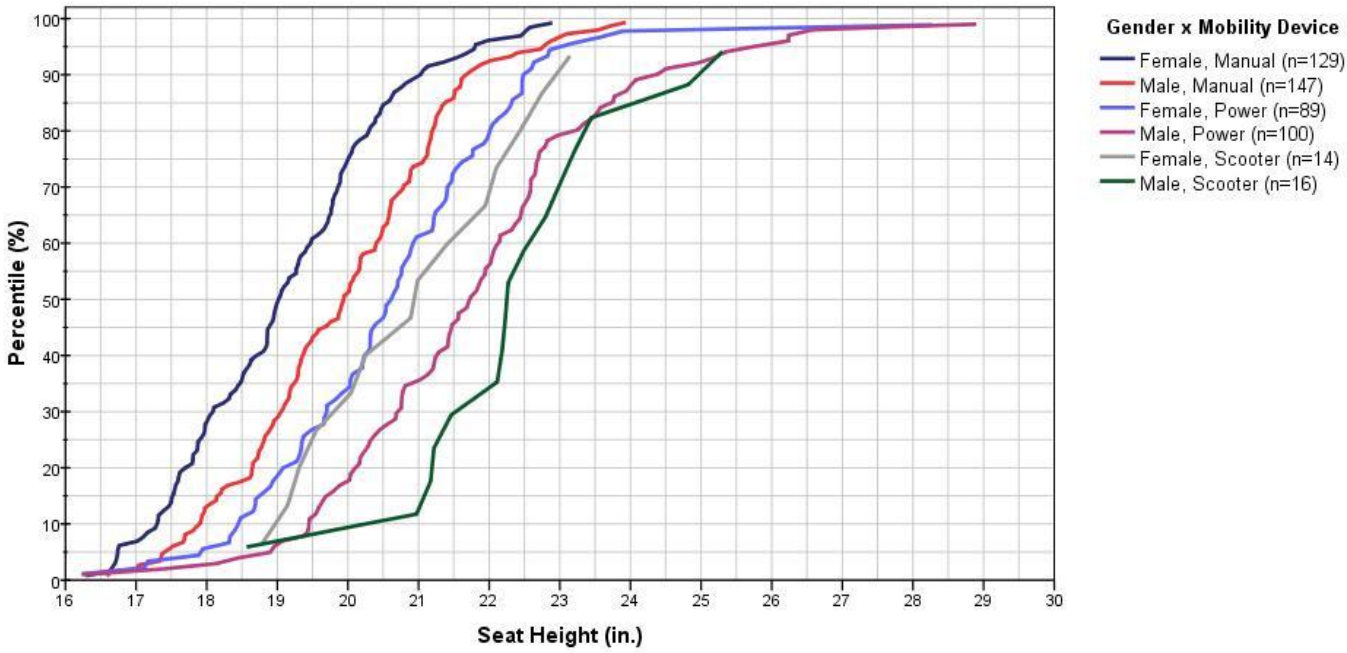

Figure 2: Cumulative percentile graph with six sub samples

C. Identifying Extreme Cases

These photographs illustrate some of the extreme cases of individuals who would be outside the recommended range.

Very High Seat Heights	
	The seat height of tilted seats was measured at the highest point of the seat. This individual could decline the seat angle to transfer, putting her within the recommended range.
	This individual of very small stature has a special seating and positioning system that raises him very high to improve social interaction. He could benefit from a wheelchair with an automatic adjustable seat height.
Very Low Seat Heights	
	This individual is small in stature and has a low seat on his manual wheelchair, perhaps selected to allow him to stand up and pivot transfer.

	This individual has no seating cushion, reducing her seat height by about 2 inches.
	This individual has a very low seat. The wheelchair appears to have a captain's chair seat that has been compressed due to her extreme weight.

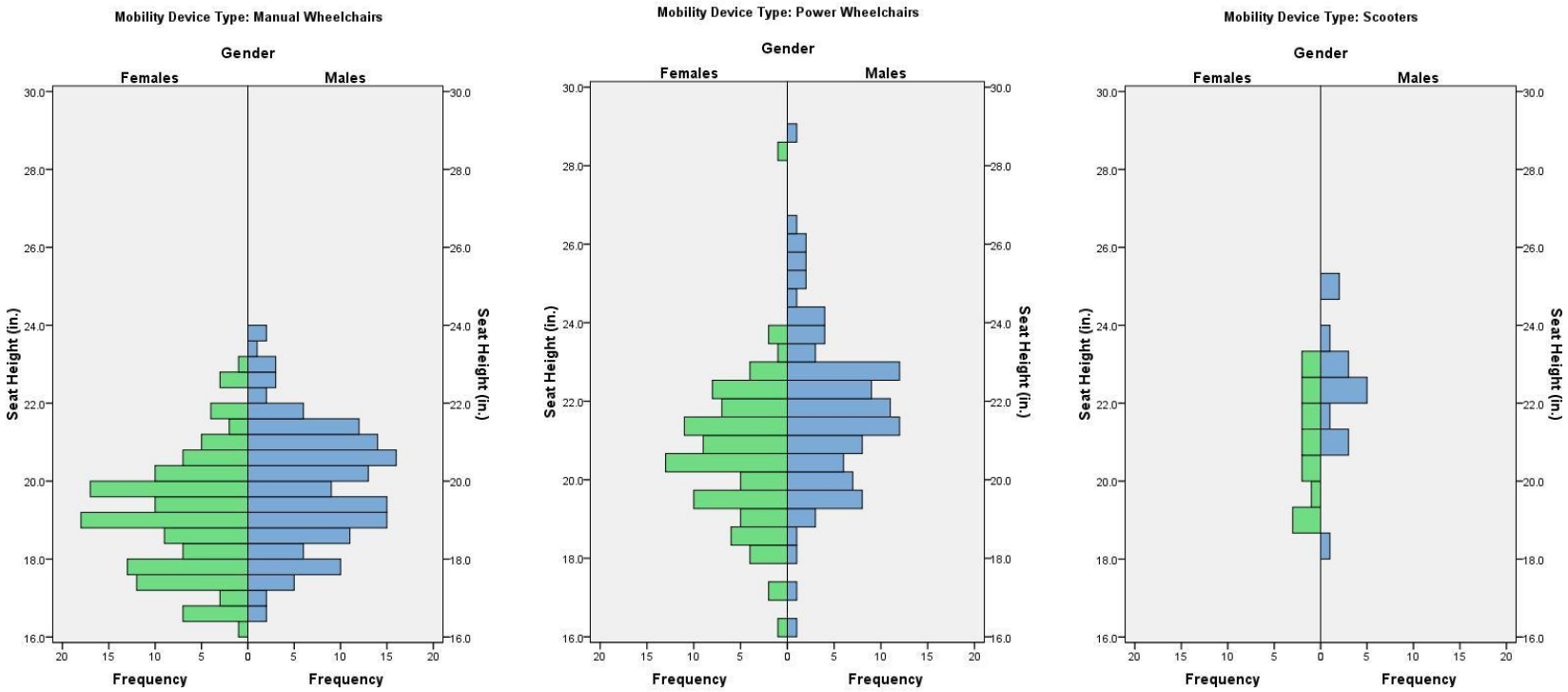

Figure 3: Histograms showing the frequency counts of measured seat heights for females (green) and males (blue) for manual wheelchairs (left), power wheelchairs (middle) and scooters (right). The histograms also help to identify extreme values and outliers, as can be observed in the case of the power wheelchair users.

Key Findings and Recommendations

Based on the options considered, the range of 17-25 in. is most appropriate for accommodating the full range of wheeled mobility device users.

The data presented above were obtained using an interactive database interface that allows us to explore the implications of different proposals for standards. Additional analysis is possible.

References

Steinfeld, E., Maisel, J., Feathers, D., and D'Souza, C. (2010). Anthropometry and standards for wheeled mobility: An international comparison. Assistive Technology 22(1): 51-67.

Steinfeld, E., Paquet, V., D'Souza, C., Joseph, C., and Maisel, J. (2010). *Anthropometry of wheeled mobility: final report.* Report prepared for the U.S. Access Board, Retrieved December 31, 2010, from http://www.udeworld.com/anthropometrics

DESIGN RESOURCES

DR-01 Analysis of Seat Height for Wheeled Mobility Devices

University at Buffalo
School of Architecture and Planning

3435 Main Street, 114 Diefendorf Hall
Buffalo, NY 14214-3087

Phone: (716) 829.5902 | TTY: (716) 829.3758

Email: ap-idea@buffalo.edu

Fax: +1 (716) 829.3861