DESIGN RESOURCES

DR-17 Knee and Toe Clearances for Wheeled Mobility Users

Center for Inclusive Design and Environmental Access

DR #17: Knee and Toe Clearances for Wheeled Mobility Users

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Question: What are the most appropriate dimensions for knee and toe clearance beneath design elements to facilitate a forward approach by wheeled mobility users?

Issue and Importance to Universal Design

Adequate space without an obstruction under a design element to the floor is essential for WMD users to approach sufficiently close in a forward direction to access equipment, controls, goods and other items, and to participate effectively in activities such as eating and work. Such clearance space is also critical when using building elements like bathroom sinks, drinking fountains, kitchen counter-tops, information kiosks and ATM machines.

Existing Research/Evidences

For the most part, designers rely on provisions described in accessibility standards and guidelines, such as the U.S. ADA-ABA Accessibility Guidelines (Access Board, 1998) as the primary reference for determining knee and toe clearance dimensions. However, these guidelines consider clearances for knee and toe space separately. We believe that knee and toe space requirements work together and that it would be more effective to present them in a way to avoid confusion in design application and compliance reviews.

There are no studies in the recent decade that have specifically analyzed or provided research based guidance on knee and toe clearance dimensions. Published research that provide summary statistics on wheeled mobility user anthropometry (e.g., Das and Kozey, 1999; Paquet and Feathers, 2004) are the most likely source for a few of the relevant dimensions such as knee height.

As part of the Anthropometry of Wheeled Mobility (AWM) project, the IDeA Center has been developing a comprehensive anthropometry database of manual chair, powered chair and scooter users in the U.S. (Steinfeld et al., 2010). Based on measurements of structural body and mobility device dimensions obtained from 320 manual wheelchair, powered wheelchair and scooter users, recommendations for knee and toe clearance in the form of graphical accommodation models were developed.

Quality of Existing Evidence

Design tools that provide guidance on knee and toe clearance dimensions are generally lacking. Current design guidelines for knee and toe clearance dimensions are limited and inadequate for dealing with the myriad of design situations wherein these clearance dimensions come into play.

Existing Design Guidelines

Current accessibility guidelines in the U.S. such as the ADA-ABA Accessibility Guidelines provide dimensions for maximum and minimum depths for (a) toe clearance space between the floor and 9 inches above the floor, and (b) knee clearance space between 9 inches and 27 inches above the floor.

Summary of the AWM findings

Measurement of structural body dimensions were performed using a coordinate measuring device (Paquet and Feathers, 2004). The analysis of knee and toe clearance requirements made use of five anthropometric dimensions measured on the right side from 158 manual wheelchair users. These comprised of:

1. Foot clearance height (FCH): the vertical height from the floor to the dorsal foot point (i.e. near the crease of the foot and the lower leg).
2. Foot clearance depth (FCD): the horizontal distance from the anterior-most point on the person or wheelchair, to the dorsal foot point on the right foot.
3. Knee clearance height (KCH): the vertical distance from the floor to the superior aspect of the right knee.
4. Knee clearance depth (KCD): the horizontal distance from the forward-most point on the person or wheelchair, to the forward-most aspect of the right knee.
5. Abdomen extension depth (AED): the horizontal distance from the forward-most point on the person or wheelchair, to the forward-most aspect of the abdomen.

Using these five dimensions, we developed a new representation method for knee and toe clearances that can be related directly to landmarks on the body and device. Four different accommodation models were developed depicting knee and foot clearance spaces for manual wheelchair users for different positions of the individual in relationship to the built element (Figures 1 - 4):

1. The forward-most point of the body or equipment touching a facing wall (Anterior-most point as reference)
2. The crease of the foot and lower leg in contact with the built element (Dorsal foot point as reference)
3. The forward-most point of the knee in contact with the element (Distal Knee point as reference)
4. The forward-most point of the abdomen in contact with the element (Anterior-most abdomen point as reference).

The shaded areas in the figures depict the envelope of the space required by a specified proportion of manual wheelchair users. These graphical representations provide information on the minimum knee and foot clearance height and depth needed in order to accommodate a specific proportion of the sample (e.g. 95%, 90%, 75%, etc.).

Each model applies to a different design scenario. The designer should select the model that is most appropriate for the task or activity to be conducted at a location and physical constraints in the environment. For example, a safe under an ATM may restrict the depth of the toe clearance, thus the first model would be used. But, in designing a desk for filling out a job application, there is no technical reason for restricting the depth of toe clearance but the leading edge of the desk should be as close to the abdomen as possible. Thus the fourth model is more appropriate.

1. Reference: Anterior-most point

Description: This model is applicable when it is required that users approach the element close enough such that the forward-most (anterior) point of the user or wheelchair comes in contact with a wall or barrier. The depth dimensions for foot and knee clearance and abdomen extension are referenced from this contact point.

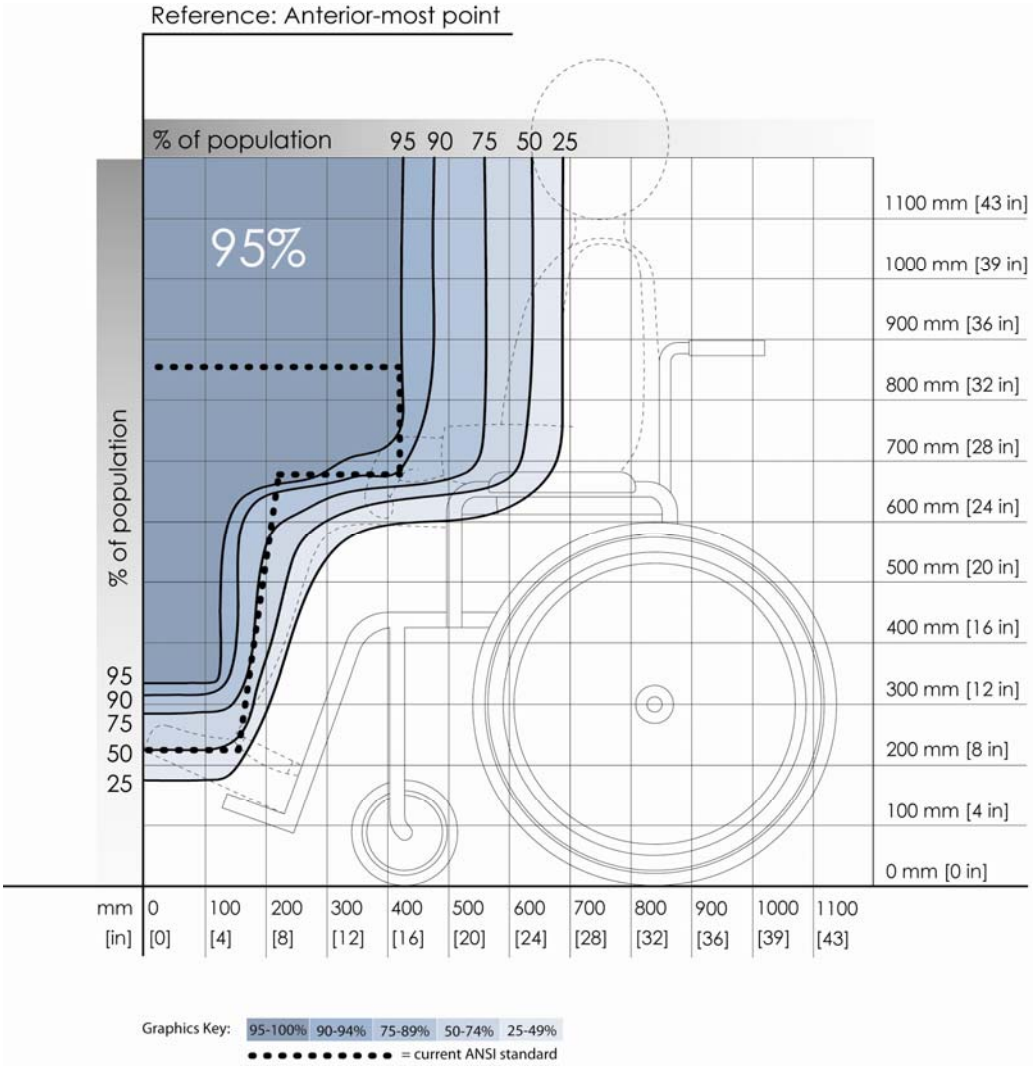

Figure 1: Knee and toe clearances for manual wheelchair users (*n*=158) referenced from the anterior-most point of the person or mobility device.

Examples of Application: Design elements such as drinking fountains, bathroom sinks and other wall-mounted features require users to approach as close as possible for successful use of the principal design feature (e.g. spout, faucet, etc.).

2. Reference: Dorsal foot point

Description: This model is applicable when providing foot clearance space is possible but availability of knee clearance space is limited due to the design element extending near to the floor. Providing adequate foot clearance height (7in -13 in) and depth (6in -10in) would allow users to approach the element close enough such that the dorsal foot point (the crease of the foot and lower leg) or higher comes in contact with the design element. This allows more users to reach forward to the reference plane located at the dorsal foot point in contrast to providing no clearance space at all (see DR#20 on Reaching abilities in the forward direction).

The depth dimensions for foot clearance (negative) and knee clearance and abdomen extension (positive) are referenced from this contact point. Negative distances on the horizontal axis indicate dimensions that project into the design element, and positive distances indicate dimensions that protrude out in relation to the reference plane.

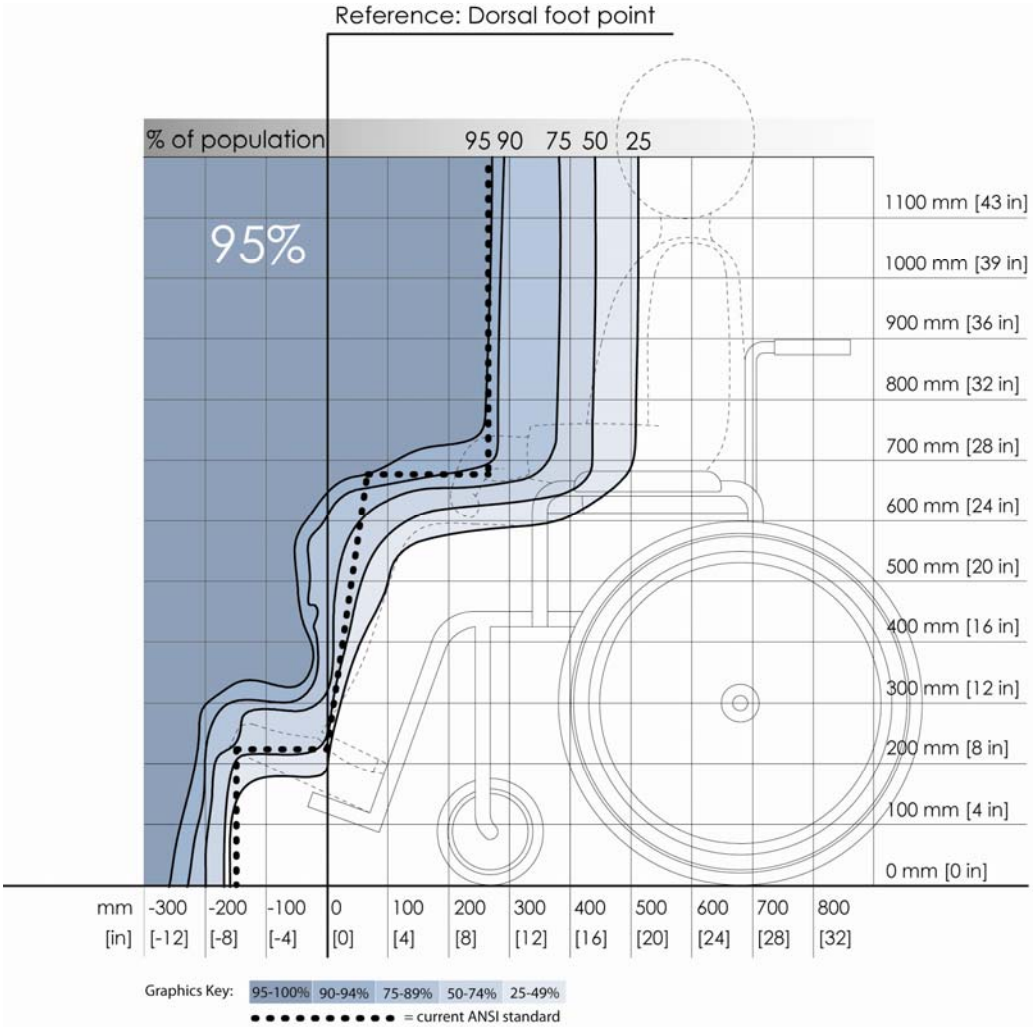

Figure 2: Knee and toe clearances for manual wheelchair users (*n*=158) referenced from the dorsal foot point.

Examples of Application: Counter tops in kitchens with base cabinets, countertops at banks, customer service areas, and pharmacies are all examples of the application of this resource.

3. Reference: Distal Knee Point

Description: This model is applicable when the reach target or work surface (typically located at a height greater than 27 in. from the floor) needs to be close to the user, but available knee clearance space is limited due to the design element extending midway to the floor. Designs based on this model would allow users to approach the element close enough such that the forward-most point of the knee comes in contact with the element.

The depth dimensions for foot and knee clearance (negative) and abdomen extension (positive) are referenced from this contact point. Negative distances on the horizontal axis indicate dimensions that project into the design element, and positive distances indicate dimensions that protrude out in relation to the reference plane.

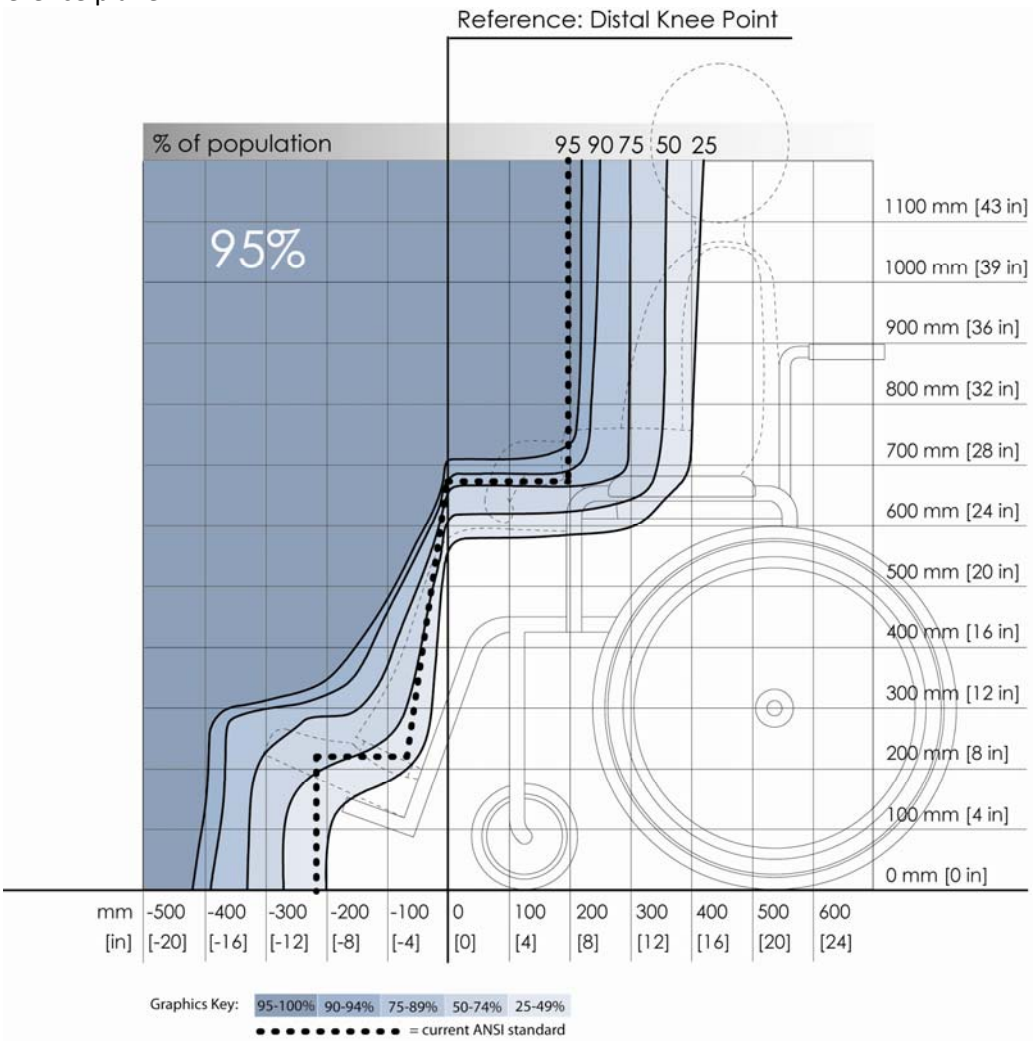

Figure 3: Knee and toe clearances for manual wheelchair users (*n*=158) referenced from the forward-most (distal) point on the knee.

Examples of Application Similar to the dorsal foot point as a reference, this can apply to many types of countertops. The difference here is that this assumes that the foot space is provided but the knee is restricted, i.e., no base cabinets or wall under the countertop, but a counter surface or table that must be thick or very low to achieve other objectives.

4. Reference: Abdomen anterior-most point

Description: This model is applicable when designing for a large reach area or work surface (typically located at a height greater than 27 in. from the floor) with ample/unrestricted foot and knee clearance space. Designs based on this model would allow users to approach the element close enough such that the forward-most portion of the abdomen comes in contact with the element.

The depth dimensions for foot and knee clearance (negative) are referenced from this contact point. Negative distances on the horizontal axis indicate dimensions that project into the design element in relation to the reference plane.

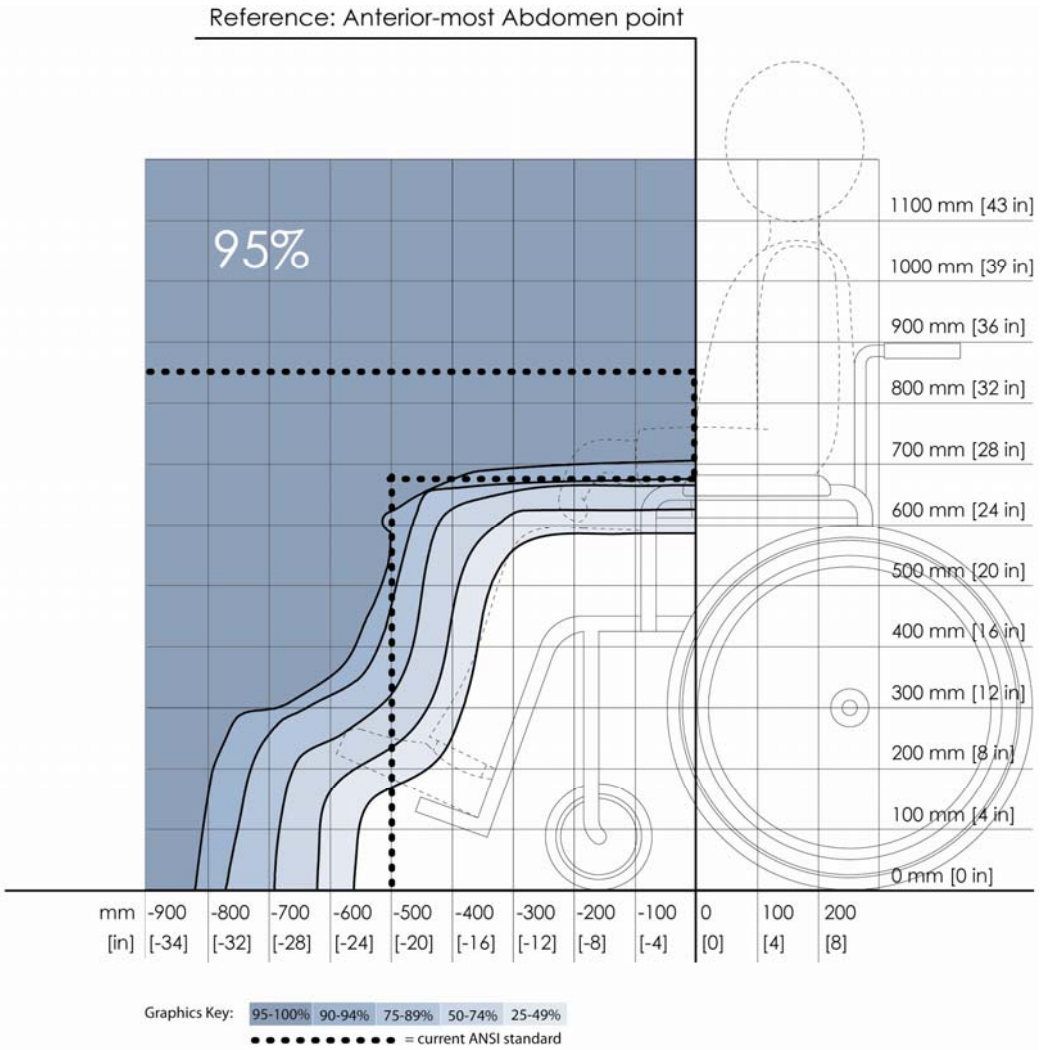

Figure 4: Knee and toe clearances for manual wheelchair users (*n*=158) referenced from the anterior-most point of the abdomen.

Examples of Application: Dining tables and desks that typically have unrestricted foot and knee clearance, and large surface areas. This design resource should be used in conjunction with the reach range data for locating controls and devices if the surfaces have such devices on them.

General Guidelines for Knee and Toe Clearances

The accommodation models are very useful for designers and product manufacturers. For simplicity, it would be good if standards had only one illustration. The following dimensions on knee and toe clearances should be used to accommodate 95% of our study sample on all four dimensions:

- Toe clearance depth: 127 mm (5 in.) maximum, measured from wall
- Toe clearance height: 356 mm (14 in.) minimum , measured from the floor
- Knee clearance height: 711 mm (28 in.) minimum, measured from the floor
- Knee clearance depth: 305 mm (12 in.) minimum, measured from the leading edge of the toe clearance or 406 (16 in.) minimum, measured from the wall if there is no separate toe clearance.
- Knee clearance depth for workstations, lunch counters and dining tables: 813 mm (32 in.) minimum measured from the wall.

Further, knee clearance should not be sloped, in other words, it should be the same depth throughout. Toe clearances at cabinets and other locations without knee clearance should be a minimum 127 mm (5 in.) high but a minimum or maximum limit is not necessary. Also, overlap of toe clearance and turning clearances can be allowed.

Note 1: Only data on manual wheelchairs has been currently provided.
Note 2: The data does not consider dimensions of wheelchair arm rests, as most wheelchairs currently have swing-away or detachable arm-rests.
Note 3: For a given model, the precise dimensions for clearance height and depth would depend on the proportion of individuals the designers intends to accommodate, the nature of the task/activity, and physical constraints in the design environment.

Research Needs

The data provided here is only a starting point in accessible design for tasks requiring knee and toe clearances beneath design elements in a forward approach. Additional research is required to better describe the extent of knee and foot clearances needed for different tasks and situations (e.g. when needing to reach and grasp, lift objects, or operate controls) and its impact on task performance, towards developing more comprehensive and inclusive design criteria.

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References

Accessibility Standards Documents
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Anthropometry Research Studies

Das, B., Kozey, J. W., 1999. Structural anthropometric measurements for wheelchair mobile adults. Applied Ergonomics 30 (5), 385-390.

Paquet, V., Feathers, D., 2004. An anthropometric study of manual and powered wheelchair users. International Journal of Industrial Ergonomics 33 (3), 191-204.

Relevant Design Resources

Design Resource #16: Clear floor area for wheeled mobility when reaching or grasping

Design Resource #20: Functional reach capability for wheeled mobility users

DESIGN RESOURCES

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