

SMA Funded Handrail Testing and Research



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Introduction

Presentation to the ICC/ANSI A117 Committee January 5, 2009

Since its inception in 1988 the Stairway Manufacturers' Association has actively participated in the development of building codes and standards and made significant contributions to the advancement of the body of knowledge essential to the improvement of the stair industry and its products and services.

SMA funded research and testing is the foundation of our efforts to meet the needs of our customers by providing safe stairways with the aesthetic qualities they demand.

The Stairway Manufacturers' Association funded the enclosed comparative study of persons with disabilities using handrails on stairs and ramps. The need for such a study has been cited in the proceedings of the ICC/ANSI A117 Committee and the International Building Code® pertaining to proposed changes that would allow additional handrail shapes. This study is the first of its kind to show preference of handrail shapes in the actual use of stairs and ramps and reveals several interesting properties of handrails related to shape. In correlation with other SMA funded studies referenced in this document this represents the very best evidence available related to prescribing the shapes of handrails. Although each of the participants in this study are described as having various degrees of disability it might be reasoned that all users have varying degrees of disability or...ability. On this basis SMA funded research provides proof of reasonable advantages for all users. It further proves assumed disadvantages to adding additional handrail shape options based only on opinion lack merit.

It will always be quite impossible to test all the combinations of handrail shapes and disabilities but we could benefit from additional testing. The SMA has and will continue to pursue such options. For now though we have enough information on the topic of handrail shape to seriously question the adequacy of our current codes and standards. Do they truly represent the best we can offer to improve access?

Many years ago action was taken with very limited information, to invoke changes that restricted the shape of handrails. This study and other works presented to this committee prove reasons to allow and prefer other shapes. It is time once again to invoke change but with greatly improved understanding. We can make the codes and standards better now.

The enclosed report is augmented by more than 294 tests that were video taped. The study report was completed January 2, 2009 and examples of these videos will be included in the presentation to the A117 committee on January 5, 2009.

Uses and Preferences of Handrails: People with Mobility and Visual Impairments and Limitations

A Pilot Study

Conducted by:

Access to Participation Consulting
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January 2, 2009

Acknowledgements

This study was funded by:

Stairway Manufacturers' Association
385 Garrisonville Rd., Suite 116
Stafford, VA 22554
Phone Toll-Free: (877) 500-5759
www.stairways.org

The handrails were provided by:

Builders Stair Supply
9217 Watson Industrial Park
Crestwood, MO 63126

The site of testing was at the facilities of Paraquad, a large Center for Independent Living serving the greater St. Louis metropolitan area. This project was reviewed and approved by Robert Funk, CEO of Paraquad.

Paraquad
Enabling Mobility Center (EMC)
5240 Oakland Ave.
St. Louis, MO 63110

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Purpose

The purpose of this pilot study was to describe differences in handrail use and preferences by people with different types of mobility impairments and limitations.

Specific Aims

Describe the frequency of handrail use at different home and community sites by people with mobility impairments and limitations.

Depict the importance of handrails at different home and community sites by people with mobility impairments and limitations.

Explain how handrails are used by people with mobility impairments and limitations.

Rate the importance of handrail features by people with mobility impairments and limitations.

Compare preferences of four groups of people with mobility impairments and limitations for three different types of handrails by people with disabilities.

Background

Codes and Standards related to the regulation of handrail shapes (referred to as profiles in the building industry and also as cross-sections in some codes and standards) could benefit from a better understanding of how handrails are used by persons with disabilities. No reports of handrail testing has addressed the shape of handrails as used by people with disabilities, yet access to buildings and to areas within buildings may be influenced by the shape of handrails installed. Exemplars of several categories of handrails with differing shape parameters need to be compared by testing their use by persons with different types of disabilities. This study will augment the results of a study that tested able-bodied people and provided a prescriptive definition of handrail shapes of equivalent grasp ability <http://www.sgh.com/news/articles.cfm?type=2&thisyear=2008>

Handrails can provide assistance in ascending and descending stairs and ramps for people without disabilities and reduce falls (Dusenbury, Simpson & DelloRusso, 2009). Prior research on the use of handrails has found that people grasp the handrail differently for guidance, balance, fall prevention and means of acceleration or arresting movement. For people without disabilities, the form of the handrail, grasps and the strategies used to accomplish these actions vary. At issue is whether people with disabilities use the same or different strategies and grasps for the different shaped handrails as those without disabilities. Two common types of handrails are categorized as Type I and Type II by the International Building Code® (IBC) as published by the International Code Council (ICC) in the 2007 supplement to the 2006 IBC, <http://www.iccsafe.org/cs/codes/2007-08cycle/2007Supplement/IBC07S.pdf> p 91-92. In general Type I handrails may be of any shape provided the perimeter of the profile is greater than 4 inches (102 mm) and less than 6-1/4 inches (159 mm). Type II handrails have a regulated shape with a perimeter greater than 6-1/4 inches (159 mm) with certain, defined, opposed, finger/thumb-recesses on each side.

Handrail use by people with disabilities may be influenced by the shape of the handrail. Type I handrails may be gripped around the entire perimeter. Type II handrails may be gripped only on the upper portions of the handrail, not the entire perimeter. The issue to be addressed in this pilot study is: What influence on ascending and descending

stairs and ramps are found for people with different mobility impairments and limitations when they use the entire handrail perimeter (Type I) or only a proportion of the handrail (Type II)?

Method

Equipment

The following types of handrails were tested (See Figure 1)

HR1 – Type 1, industry standard 1-1/2 inch (38 mm) diameter round,

HR2 – Type II, industry standard 6010 profile – 2-1/4 inches (57 mm) wide x 2-3/8 inches (60 mm) high, min 5/16 inch (8 mm) recess, and

HR3 – Type II, 2-1/2 inch (64 mm) wide x height > finger length TBC, > 5/16 Inch (8mm) recess TBD.

The handrails were mounted as follows:

Handrails HR1 and HR2 had typical baluster mountings and bracket mountings on stairs,

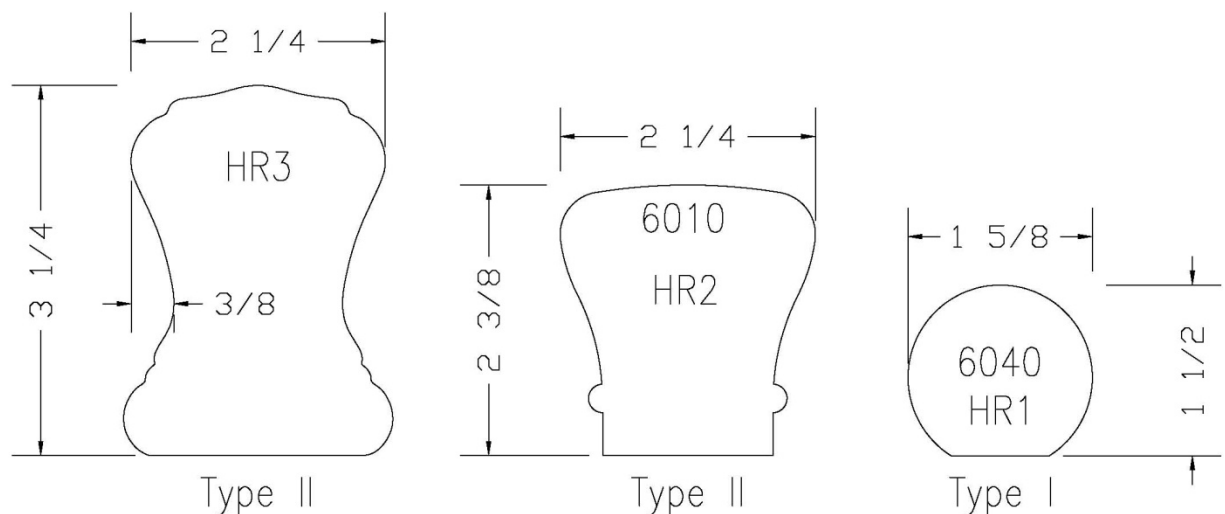
Handrails HR1 and HR2 had only bracket mountings on ramp, and

Handrail HR3 had only baluster mountings in all locations.

The height of all the handrails was 36 inches¹ (also of note this is the median of the range 34"-38" as required in both the IRC and IBC model codes)

Figure 1

Handrail Types Tested: HR1, HR2 and HR3



¹ In determining the testing protocol of preferred handrail height, the reference used was the Australian study; Seeger, B.R. and Bails, J.H. Ergonomic Building Design for Physically Disabled Young People. Assistive Technology, 1990; 2: 79-92. This study recommendation for handrail heights and current codes were considered in selecting a constant height for all tests.

Participants

All of the participants in this pilot study reported having difficulty moving up and down stairs and ramps. All participants lived within the St. Louis metropolitan area and were able to read at or above the sixth grade level. The participants included individuals with different racial backgrounds in portion with the racial representation of the city of St. Louis (See Table 1). Prior to participation in this study all participants signed both an informed consent and an agreement for use of the video clips made of them ascending and descending stairs and ramps.

Table 1
Demographics

Total Sample	N=28			
Test Age	Range	23-75	Mean	50.5
Gender	Male			Number of Participants
	Female			10
Race	White			18
	Black/African American			12
	Latino/Hispanic			15
Marital status	Married			1
	Divorced			5
	Widowed			5
	Separated			3
	Never been married			2
Highest grade completed				13
	Never attended or only kindergarten			0
	Grade 1-11			4
	Grade 12/GED			10
	College 1-3 years			7
	College 4 or more years			7
Annual household income				
	\$0 - \$14,999			12
	\$15,000 to \$34,999			10
	\$35,000 to \$54,999			1
	\$55,000 to \$74,999			1
	\$75,000 or more			1
	I prefer not to answer			3

Participants were drawn from the following categories of mobility impairments and limitations:

No Device Group (n=6) Members of this group use no mobility device but have great difficulty walking across one room and reported that they use stairs and ramps when they participate in their communities. The participants consisted of 6 adults with a mean age of 55.8 years. Participants in this group were all female, 83% were African American and 17% were White.

Cane Group (n= 8) Individuals who use canes to assist their walking and who reported using stairs and ramps were selected for this group. The participants were 8 adults with a mean age of 51.6 years. Participants in this group were predominantly female (88%). The racial composition was 63% African American, 25% White, and 12% Hispanic/Latino.

Blind/Low Vision Group (n=7) This group included individuals with differing levels of visual limitations from those who are unable to see to those who see with difficulty. The level of visual impairment was established by self-report. The members of this group reported that they use stairs and ramps when they participate in their communities. The participants were 7 adults with a mean age of 51.6 years. This group included 71% male and 29% female. The races in this sample were 57% White and 43% African American.

Manual Wheelchair Group (n=7) Included in this group were individuals who use manual wheelchairs as their means of mobility, have used a manual wheelchair for at least two years, reported no wheelchair related accidents in the past two years and reported using handrails to assist them to ascend ramps. The participants were 7 adults with a mean age of 43.9 years. Individuals included in this group were 57% male and 43% female. Participants in this group were predominantly White (71%) while 29% were African American.

Procedures

Overview

Four groups of 6 to 8 people with disabilities were convened at Paraquad, Center for Independent Living in St. Louis, Missouri. The groups were convened on different dates. The sequence of events for each of the groups began with consenting participants, a short survey of the individual's community participation and current use of handrails. Next, each member of each group was taken to the Enabling Mobility Center where they used three different types of handrails to ascend and descend stairs and ramps, except for the members of the wheelchair group who used the handrails for ascending the 1/12 ramps. All participants individually rated their handrail preferences and then convened as a group to discuss and rank the handrails. Refreshments were served and after completion of the group session the participants were paid for their time and effort.

Part One: Survey

Participants were introduced to study staff and asked to complete an abbreviated version of a survey of participation (Survey of Participation and Receptivity of the Community - SPARC) that included questions on how frequently they go to sites in their communities (18 locations²), how important handrails are at community sites and how often they use handrails if available (See Table 2 and Appendix A). After the surveys were completed, participants were told about the events that were to transpire during the day. All of these activities were completed in a room at Paraquad that was different from the EMC where the handrails were located.

Table 2

Sample of community participation questions

Location	How frequently do you go?	If available, how often do you use handrails at the specific location?	How important is using handrails at the specific location?
1. Grocery stores ☐ I prefer not to answer	☐ Never (go to #2) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important

Part Two: Handrail Use

Participants went into the Enabling Mobility Center (EMC) located within Paraquad where they were asked to try all three handrails to ascend and descend ramps, stairs or both. The trials for the participants included ascending using right side handrail, descending using right side handrail, ascending using left side handrail and descending using left side handrail. The

² The frequency of going to community sites data was used to limit the community sites reported for the questions on importance and use of handrails. Only 11 of the 18 were included in the SPARC because the other sites did not have handrails.

same sequence of events was repeated for each type of handrail for the ramp (1/12 slope) and for stairs (members of the Manual Wheelchair group did not use the stairs). Due to the time needed to change the handrails, all of the participants tested one type of handrail before the handrails were changed. The sequence of handrails tested was randomized and occurred in a different order to reduce a sequence and/or fatigue bias (See Table 3). In general, participants in the No Device, Blind/Low-Vision and Cane User groups ascended and descended the ramp and stairs 24 times, 4 times for each of the 3 types of handrails for the ramp and 4 times for each of the 3 types of handrail for the stairs. However, some participants were not able to participate in all aspects of the trial. One example of this type of situation occurred when an individual needed to use their ambulatory device (cane) on their dominant (strong) side. In this case the right side handrail was not tested. The wheelchair user group members ascended and descended the ramp 12 times, 4 times for each type of handrail. However, most wheelchair users did not use the handrails when they descended the ramp. The participants were accompanied by a physical therapy assistant or occupational therapist to reduce risk of falls. After each participant completed ascending and descending the ramp, they were asked to rate the handrail. Then the participant was asked to ascend and descend four stairway steps and rate the handrail. A 1 - 4 rating scale (1 = poor, 2 = fair, 3 = good, 4 = excellent) was used for each of the following characteristics: balancing (stability), pulling(ascending), pushing(descending), gliding (guidance), safety, aesthetic appeal, and ability to grip.

Table 3a

Sequence for all groups with handrail order - No device and Cane User Groups

<i>No Device Group</i>		<i>Cane User Group</i>	
HR2		HR1	
RAMP	STAIRS	RAMP	STAIRS
Ascend right hand	Ascend right hand	Ascend right hand	Ascend right hand
Descend right hand	Descend right hand	Descend right hand	Descend right hand
Ascend left hand	Ascend left hand	Ascend left hand	Ascend left hand
Descend left hand	Descend left hand	Descend left hand	Descend left hand
<u>Rate the handrail</u>	<u>Rate the handrail</u>	<u>Rate the handrail</u>	<u>Rate the handrail</u>
HR1		HR3	
RAMP	STAIRS	RAMP	STAIRS
Ascend right hand	Ascend right hand	Ascend right hand	Ascend right hand
Descend right hand	Descend right hand	Descend right hand	Descend right hand
Ascend left hand	Ascend left hand	Ascend left hand	Ascend left hand
Descend left hand	Descend left hand	Descend left hand	Descend left hand
<u>Rate the handrail</u>	<u>Rate the handrail</u>	<u>Rate the handrail</u>	<u>Rate the handrail</u>
HR3		HR2	
RAMP	STAIRS	RAMP	STAIRS
Ascend right hand	Ascend right hand	Ascend right hand	Ascend right hand
Descend right hand	Descend right hand	Descend right hand	Descend right hand
Ascend left hand	Ascend left hand	Ascend left hand	Ascend left hand
Descend left hand	Descend left hand	Descend left hand	Descend left hand
<u>Rate the handrail</u>	<u>Rate the handrail</u>	<u>Rate the handrail</u>	<u>Rate the handrail</u>

Table 3b

Sequence for all groups with handrail order – Blind/Low-Vision and Wheelchair User Groups

Blind Low Vision Group		Wheelchair Group
HR3		HR2
RAMP	STAIRS	RAMP
Ascend right hand	Ascend right hand	Ascend right hand
Descend right hand	Descend right hand	Descend right hand
Ascend left hand	Ascend left hand	Ascend left hand
Descend left hand	Descend left hand	Descend left hand
<u>Rate the handrail</u>	<u>Rate the handrail</u>	<u>Rate the handrail</u>
HR1		HR1
RAMP	STAIRS	RAMP
Ascend right hand	Ascend right hand	Ascend right hand
Descend right hand	Descend right hand	Descend right hand
Ascend left hand	Ascend left hand	Ascend left hand
Descend left hand	Descend left hand	Descend left hand
<u>Rate the handrail</u>	<u>Rate the handrail</u>	<u>Rate the handrail</u>
HR2 – B		HR3
RAMP	STAIRS	RAMP
Ascend right hand	Ascend right hand	Ascend right hand
Descend right hand	Descend right hand	Descend right hand
Ascend left hand	Ascend left hand	Ascend left hand
Descend left hand	Descend left hand	Descend left hand
<u>Rate the handrail</u>	<u>Rate the handrail</u>	<u>Rate the handrail</u>

Part Three: Group Discussion

The participants returned to a room where they participated in a structured discussion about their experiences with and preferences for the three types of handrails. Participants were asked about how they used handrails for each of the following: balancing, pulling (ascending), pushing (descending), guidance grasping, safety, and aesthetic appeal. At the end of the discussion, the group was asked to vote for their favorite handrail to obtain their preferences for balancing (stability), pulling (ascending), pushing (descending), gliding (guidance) and safety. In addition, the participants were asked how important the handrail aesthetic appeal, texture of the handrail surface, height of handrail and ability to grip were. Participants were provided with a picture of each type of handrail and were reminded of the order they had used the different handrail types. Immediately after the focus group participants left, the research team held discussions to review their notes for themes in response to overarching questions, frequency of responses to topical questions and comments on handrails that had been strongly felt.

Part Four: Videotapes

All participants in each mobility impaired and limited group were videotaped as they used the different handrails to ascend and descend stairs and ramps. Video tapes were made from a position that provided a frontal view of the study participants using the handrails with a focus on their hands.

Results

Survey Responses

The data from the short survey of handrail use and importance during community participation provide an indication that cane users and people who have difficulty walking but use no mobility device often use handrails while people who are blind rarely use handrails. Manual wheelchair users do not use handrails frequently and find handrails to be generally unimportant for ascending and descending ramps. Handrail use at the study participant's home and in homes of their friends and relatives was reported as often with cane users almost always using handrails in their own homes. The highest handrail use outside of homes was at large stores, restaurants and places of worship (See Table 4).

Table 4
Frequency of Handrail Use

Site	No Device	Blind	Cane	Wheelchair	Total Sample
Home	2.50	2.86	3.50	2.71	2.89
Large store	2.83	2.71	3.13	1.57	2.56
Home Family Friends	3.17	3.00	2.13	1.86	2.54
Restaurants	2.50	2.86	2.63	2.00	2.50
Worship	2.83	2.43	2.38	1.86	2.37
Doctor	2.67	2.43	2.75	1.00	2.21
Movie	3.17	1.57	1.75	2.00	2.12
Malls	2.17	2.71	2.00	1.29	2.04
Exercise	2.17	1.43	3.00	1.43	2.01
Work	2.33	0.29	2.75	2.00	1.84
Grocery	1.67	1.57	2.50	1.57	1.83
Average Frequency of Handrail Use by Group	2.55	2.17	2.59	1.75	2.26

Rating Scale: 0 = No Response, 1 = Never, 2 = Rarely, 3 = Often and 4 = Always

Rank of Frequency of Use of Handrails by Group	2	3	1	4
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Ranking Scale: 1 = Highest ranked, 2 = Second highest rank, 3 = Third ranked and 4 = Lowest ranked

On the survey, the importance of handrails was reported to be highest by those who are blind and those who use canes. Those using no device reported less importance than the blind and cane users but more than wheelchair users. The groups reported that handrails are most important in their own homes and in the homes of their friends and relatives. Large stores, doctor offices and restaurants were reported as community sites where having handrails is somewhat important. For people who have trouble walking but use no device, handrails in movie theatres was reported as important (See Table 5).

Study participants described the use of handrails for several functions. All three non-wheelchair groups reported 'always' using handrails to guide them going up and down stairs. They use handrails 'often' when going up and down ramps. Similar results were found for handrail use to balance during ascent and descent. The No Device and Cane groups 'often' use handrails to pull up or push (restrain) going up or down stairs or ramps. Not surprisingly, the Blind/Low Vision and Wheelchair user groups rarely use handrails to pull up or push down stairs or ramps with the exception of when wheelchair users pull themselves up ramps. For all groups except the wheelchair user group, handrails were reported to be used most often for safety reasons.

Table 5
Importance of Handrail Use

Site	No Device	Blind	Cane	Wheelchair	Total Sample
Home	2.50	3.29	3.88	3.00	3.17
Homes Friends	2.83	3.00	2.75	3.14	2.93
Large stores	2.67	2.86	3.50	2.14	2.79
Doctor	3.00	3.14	3.25	1.43	2.71
Restaurant	2.67	3.14	2.38	2.71	2.72
Exercise	2.00	2.86	3.50	2.14	2.63
Grocery	2.17	2.71	3.25	2.14	2.57
Worship	2.50	3.29	2.25	2.29	2.58
Mall	2.17	3.71	2.13	2.00	2.50
Movie	3.00	2.14	2.00	2.71	2.46
Beauty Shops	2.83	1.86	2.50	2.00	2.30
Average Importance of Handrails Use by Group	2.58	2.91	2.85	2.34	2.67

Rating Scale: 0 = No Response 1 = Very unimportant 2 = Unimportant, 3= Important and 4 = Very important

Rank of Importance of Handrail Use by Group	3	1	2	4
Ranking Scale: 1 = Highest ranked, 2 = Second highest rank, 3 = Third ranked and 4 = Lowest ranked				

Table 6
Different uses of handrails by people with disabilities

a. How often do you use handrails to guide you when going	No Device	Blind	Cane	Wheelchair	Total Sample
Upstairs	4.00	3.71	3.88	2.43	3.50
Down stairs	4.00	3.71	3.88	2.14	3.43
Up ramps	3.00	3.57	3.88	2.57	3.29
Down ramps	3.00	3.57	3.88	2.29	3.21
Total	3.50	3.64	3.88	2.36	3.36
b. How often do you grasp handrails for balance when going	No Device	Blind	Cane	Wheelchair	Total Sample
Upstairs	3.83	3.71	3.88	2.00	3.36
Down stairs	3.67	3.71	3.88	2.00	3.32
Up ramps	3.00	3.43	3.88	2.29	3.18
Down ramps	3.00	3.43	3.88	2.14	3.14
Total	3.38	3.57	3.88	2.11	3.25
c. How often do you use handrails to pull or push	No Device	Blind	Cane	Wheelchair	Total Sample
Pull when going up stairs	3.67	2.57	3.50	2.00	2.93
Push when going down stairs?	3.50	2.57	3.25	1.71	2.75
Pull when going up ramps?	3.50	2.57	3.38	3.00	3.11
Push when going down ramps?	3.33	2.43	3.00	2.29	2.75
Total	3.50	2.54	3.28	2.25	2.88
d. How often do you use handrails for safety when going	No Device	Blind	Cane	Wheelchair	Total Sample
Upstairs	3.83	3.71	3.88	2.00	3.36
Down stairs	3.83	3.71	3.88	2.00	3.36
Up ramps	3.67	3.57	3.88	2.57	3.43
Down ramps	3.83	3.57	3.88	2.57	3.46
Total	3.79	3.64	3.88	2.29	3.40

Use Scale: 1 = Never, 2 = Rarely, 3 = Often and 4 = Always

The final survey questions on the survey asked questions about several features of handrails. Participants reported that the appearance of handrails is less important than the texture, height and grip of the handrail which were all rated as important (See Table 7). The Cane users

and Blind/Low vision participants rated the height and shape of the handrail to be important to very important.

Table 7

Importance of handrail features

How important is	No Device	Blind Cane	Wheelchair	Total Sample
The aesthetic appeal of a handrail (how it looks) to you?	2.50	2.00	2.88	2.43
The texture of a handrail (how it feels) to you?	2.83	3.43	3.25	3.29
The height of a handrail to you?	3.17	3.43	3.88	3.14
The shape of a handrail for grip to you?	3.17	3.57	3.50	3.14

Use Scale: 1 = Very unimportant, 2 = Unimportant, 3 = Important and 4 = Very important

Results

Handrail comparative testing results

When members of the four groups used three types of handrails during the controlled tests at the Enabling Mobility Center, the differences in ratings and rankings between those who use a manual wheelchair and those who do not was evident. Thus, the results of the pilot testing are presented for wheelchair users separately. Immediately after ascending and descending the ramps and again after going up and down the stairs the participants rated the handrails as poor, fair, good or excellent. All the groups rated all three types of handrails good to nearly excellent (See Table 8). The sample sizes were inadequate for a statistical analysis but these preliminary data show little difference between handrail types. When the averages of the group member responses were ranked, Type HR3 handrail had the highest rank followed by Type HR1 and Type HR2 handrails. For the wheelchair user group, the rating scores showed Type HR1 handrail scored highest while Type HR3 was the lowest.

Table 8

Individual handrail rating immediately after use and handrail type ranking

Handrail Types Group	Type HR3		Type HR2		Type HR1	
	Ramp	Stairs	Ramp	Stairs	Ramp	Stairs
No Device	3.19	2.95	2.95	2.81	3.17	2.88
Blind	3.49	3.51	2.86	3.00	3.24	3.18
Cane	3.34	3.32	3.27	3.16	3.13	3.64
Average Handrail Type Rating	3.34	3.26	3.03	2.99	3.18	3.23

Rating Scale: 1 = Poor, 2 = Fair, 3 = Good and 4 = Excellent

Handrail Type Ranking	1	1	3	3	2	2
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Ranking Scale: 1 = Highest ranked, 2 = Second highest rank and 3 = Third ranked

Wheelchair

Handrail Type Rating	2.92	0	3.23	0	3.62	0
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Rating Scale: 1 = Poor, 2 = Fair, 3 = Good & 4 = Excellent

Handrail Type Ranking	3		2		1	
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Ranking Scale 1 = Highest ranked, 2 = Second highest rank and 3 = Third ranked

After all tests of the handrail types were concluded, a group discussion was conducted. Members of each group were asked to compare the three types of hand rails and vote for the handrail they most preferred. The results show considerable differences in the preferred handrail type (See Table 9). While handrail Type HR3 was ranked as the most preferred by the three non-wheelchair user groups, the differences were not large and each group had a different order of

preference with each group ranking one handrail type as most preferred. The wheelchair user group ranked handrail Type HR1 as most preferred.

Table 9

Group preference ranking of handrail types after group discussions

Group	Type HR3		Type HR2		Type HR1	
	Ramp	Stairs	Ramp	Stairs	Ramp	Stairs
No device	2	2	3	3	1	1
Blind	1	1	3	3	2	2
Cane	2	2	1	1	3	3
Average ranking of handrail type	1.67	1.67	2.33	2.33	2	2
Handrail Rank	1	1	3	3	2	2

Ranking Scale 1 = Highest ranked, 2 = Second highest rank and 3 = Third ranked

Wheelchair

Handrail Rank	3	2	1
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Ranking Scale 1 = Highest ranked, 2 = Second highest rank and 3 = Third ranked

Results

Videotapes

The sample included 21 non-wheelchair users and 7 wheelchair users. The non-wheelchair users went up and down the ramp four times (42 clips) and stairs four times (42 clips) and did this for each of three handrails (252 clips). The 7 wheelchair users went up the ramp and down the ramp (2 clips) for each handrail test (3 clips) for a total of 42 clips. Adding the non-wheelchair and wheelchair users should have produced a total of 294 clips. However, some study participants did not do all handrail trials because they had a hand preference and felt unsafe using their non-preferred hand. The wheelchair user group rarely used handrails when descending ramps.

The videotapes were edited to provide examples of differences in the use of handrails by people in each of the four groups. The sample videos illustrate balancing, pulling (ascending), pushing (descending), guidance, grasping, and safety of handrail use as the participants go up and down stairs or ramps using different types of handrails. The responses to the handrail uses are included on each PowerPoint slide (See PowerPoint titled “HandrailVideos.ppt”).

No Device Group

People who have difficulty walking but use no mobility devices use handrails to balance by gripping and report feeling safer when using handrails. A person, who does not use a mobility device, ascended the stairs using both hands to balance, pull and to provide safety as she ascended the stairs. She gripped the handrail strongly and stated that handrails give her the feeling that she can make it up the stairs.

Cane User Group

Many of the participants who used canes used handrails to grip and pull as they ascended the ramp and stairs. One person, who used a cane, walked well and used the handrail only as a guide to her ascent or descent. Another cane user, who had much more difficulty walking, used handrails to pull as she ascended the ramp. A cane user who ascended the stairs used the handrails to balance, pull and grip. She said that handrails provided her with a sense of safety.

Blind/Low Vision Group

Many members of this group used handrails to glide their hands down the handrails. Others used handrails for grip and safety. The rating of the same handrail (HR3) by two individuals in this group differed sharply. One participant with low vision rated HR3 highly while a blind participant gave HR3 much lower ratings. Several members of this group reported that the texture (ridges) of the handrails made a difference in their ability to guide themselves up and down ramps.

Manual Wheelchair Group

Most participants of this group stated that they rarely use handrails if the slope was minimal but did use handrails when the slope became steeper. Few used handrails when descending ramps. Two individuals pulled themselves up the ramp using one hand on the handrail and one hand to push their wheelchairs. Others used both hands on both handrails.

Discussion

This pilot study of handrail use by people with mobility impairments and limitations found that handrails are used infrequently outside the home or homes of friends and relatives. The use of handrails differed in frequency and importance at various community sites. The difference in the importance of having handrails and their use may be that many community sites do not have handrails installed. The survey of how handrails are used found that people with mobility impairments who do not use wheelchairs report that handrails are used to guide them, provide balance and, most importantly, provide safety as they ascend or descend ramps or stairs. The height and shape of handrails were described as important to the study participants.

The descriptions of the overall experience in using all three types of handrails were very positive, rating them as good to excellent after the participants had used the handrails to ascend and descend ramps and stairs. Each group of participants rated the type of handrail differently but the average of the group ratings favored Type HR3 followed by Type HR1. When the groups were asked to rank the types of handrails, the results were the same with Type HR3 receiving the highest rank.

The video clips illustrated that people with mobility impairments and limitations use handrails in many different ways. As a group, the people who have difficulty walking but do not use a cane or other mobility device tended to grip the handrails and pull or push themselves as they ascended or descended stairs and ramps. Those who use canes showed various uses of handrails from purely balance to pushing and pulling. The Blind and low-vision participants often stated that the larger handrails (HR3) provided them with a greater sense of safety as they ascended and descended stairs and ramps.

Conclusion

Handrails are most often used in the homes and homes of relatives of the participants examined in this pilot study. Having handrails in community sites that are frequently visited was reported as important by many members in the study. All types of handrails tested in this pilot study were reported to be of assistance in going up and down ramps and stairs by all participants in this study. For those who did not use wheelchairs, the preference was for handrail type HR3. The wheelchair users preferred handrail type HR1. The sample sizes in the pilot study were not large enough to make statistical comparisons, which tempers any comparisons between mobility impairment groups or to people without disabilities. Further research with larger samples is needed to draw any firm conclusions with regards to handrail use and preference.

No Device User	Lisa		Balance	Excellent
Handrail	Type HR2		Pull	Excellent
Up Ramp	Right hand	Balance, grip &safety	Push	Good
Down Ramp	Left hand	Balance, grip &safety	Glide	Excellent
			Grip	Good
			Safety	Excellent
Aesthetic appeal	Good			



No Device User	Dorothy		Balance	Good
Handrail	Type HR3		Pull	Good
Up Ramp	Left hand	Balance, grip &safety	Push	Good
Down Ramp	Right hand	Balance, grip &safety	Glide	Good
			Grip	Good
			Safety	Good
Aesthetic appeal	Good			



No Device User	Betty		Balance	Good
Handrail	Type HR2		Pull	Good
Up Stairs	Right hand	Balance, pull, grip &safety	Push	Good
	Left hand	Balance, grip &safety	Glide	Good
Down Stairs	Left hand	Balance, push, glide &safety	Grip	Good
Aesthetic appeal	Good		Safety	Good



Cane User	Kelli		Balance	Good
Handrail	Type HR1		Pull	Good
Up Ramp	Right hand	Balance, glide, minor grip & safety	Push	Good
Down Ramp	Right hand	Balance, glide, grip & safety	Glide	Good
			Grip	Good
			Safety	Good
Aesthetic appeal	Good			



Cane User	Kelli		Balance	Excellent
Handrail	Type HR3		Pull	Excellent
Up Ramp	Left hand	Balance, pull, glide & safety	Push	Excellent
Down Ramp	Left hand	Balance, glide, grip & safety	Glide	Excellent
			Grip	Excellent
			Safety	Excellent
Aesthetic appeal	Excellent			



Cane User	Janet		Balance	Poor
Handrail	Type HR1		Pull	Poor
Up Ramp	Left hand	Balance	Push	Poor
Down Ramp	Right hand	Balance	Glide	Good
			Grip	Poor
			Safety	Good
Aesthetic appeal	Good			



Cane User	Marilyn		Balance	Excellent
Handrail	Type HR1		Pull	Excellent
Up Stairs	Left hand	Balance, pull, grip &safety	Push	Excellent
Down Stairs	no video		Glide	Excellent
			Grip	Excellent
			Safety	Excellent
Aesthetic appeal	Excellent			



Cane User	Rita		Balance	Excellent
Handrail	Type HR1		Pull	Excellent
Up Stairs		Balance, pull, grip & safety	Push	Excellent
Down Stairs		Balance, push, grip &safety	Glide	Excellent
			Grip	Excellent
			Safety	Excellent
Aesthetic appeal	Excellent			



Blind/Low-Vision	Randy		Balance	Excellent
Handrail	Type HR3		Pull	Excellent
Up Stairs	Left hand	Balance, push, grip &safety	Push	Excellent
Down Stairs	Right hand	Balance, glide &safety	Glide	Excellent
			Grip	Excellent
			Safety	Excellent
Aesthetic appeal	Excellent			



Blind/Low-Vision	Dantae		Balance	Fair
Handrail	Type HR3		Pull	Fair
Up Ramp	Left hand	Balance, glide, slight grip & safety	Push	Fair
Down Ramp	Right hand	Balance, glide, slight grip & safety	Glide	Poor
			Grip	Poor
			Safety	Fair
Aesthetic appeal	Poor			



Blind/Low-Vision	Gennie		Balance	Good
Handrail	Type HR2		Pull	Poor
Up Ramp	no video		Push	Poor
Down Ramp	Left hand	Glided	Glide	Poor
			Grip	Poor
			Safety	Good
Aesthetic appeal	Poor			



Blind/Low-Vision	Thomas		Balance	Excellent
Handrail	Type HR2		Pull	Excellent
Up Ramp	Right hand		Push	Excellent
Down Ramp	Left hand	Glide	Glide	Excellent
			Grip	Good
			Safety	Good
Aesthetic appeal	Good			



Blind/Low-Vision	Carol		Balance	Excellent
Handrail	Type HR3		Pull	Excellent
Up Stairs	Left hand	Balance, pull, grip & safety	Push	Excellent
Down Stairs	Right hand	Balance, glide, push, grip & safety	Glide	Excellent
			Grip	Excellent
			Safety	Excellent
Aesthetic appeal	Excellent			



Wheelchair User	Eric		Balance	Poor
Handrail	Type HR2		Pull	Fair
Up Ramp	Left & right hand	Grip & pull	Push	Fair
Down Ramp	Left & right hand	Glide & safety	Glide	Good
			Grip	Poor
			Safety	Good
Aesthetic appeal	Good			



Wheelchair User	Duane		Balance	Excellent
Handrail	Type HR2		Pull	Excellent
Up Ramp	Left & right hand	Grip & pull	Push	no use
Down Ramp	No video		Gliding	Good
			Grip	Excellent
			Safety	Excellent
Aesthetic appeal	Excellent			



Wheelchair User	David		Balance	Excellent
Handrail	Type HR2		Pull	Excellent
Up Ramp	Right hand	Grip & pull	Push	no use
	Left hand	Push wheel of wheelchair	Glide	Excellent
Down Ramp	No video		Grip	Excellent
Aesthetic appeal	Good		Safety	Excellent



Wheelchair User	Tyra		Balance	Good
Handrail	Type HR2		Pull	Good
Up Ramp	Right hand	Grip & pull	Push	Excellent
	Left hand	Push wheel of wheelchair	Glide	Poor
Down Ramp	Right hand	Glide	Grip	Excellent
Aesthetic appeal	Excellent		Safety	Good



Wheelchair User	Kerri		Balance	Good
Handrail	Type HR1		Pull	Good
Up Ramp	Right hand	Grip & pull	Push	Fair
	Left hand	Grip & pull	Glide	Excellent
Down Ramp	No video	No handrail use	Grip	Good
Aesthetic appeal	Good		Safety	Good



HANDRAIL IMPORTANCE and USE SURVEY

For this next question, please enter '0' if you prefer not to answer.

1. What is your **age**? _____
2. What is your **gender**? ☐ *Male* ☐ *Female*
3. What is your **race/ethnicity**? **(Check all that apply.)**
 - ☐ *American Indian/Alaska Native*
 - ☐ *Asian*
 - ☐ *Black/African American*
 - ☐ *Native Hawaiian/Other Pacific Islander*
 - ☐ *White*
 - ☐ *Other (specify) _____*
4. Are you of **Hispanic** or **Latino** origin? ☐ *Yes* ☐ *No*
5. Are you: **(Check all that apply.)**
 - ☐ *Married* ☐ *Separated*
 - ☐ *Divorced* ☐ *Never been married*
 - ☐ *Widowed* ☐ *Member of an unmarried couple*
6. What is the **highest grade** or year of school you have **completed**?
 - ☐ *Never attended school or only kindergarten*
 - ☐ *Grades 1 through 11*
 - ☐ *Grade 12 or GED (high school graduate)*
 - ☐ *College 1 year to 3 years (including trade school)*
 - ☐ *College 4 years or more (college graduate)*
7. What is **your personal income** from all sources? (This question is asking about your individual income only, not about your household, spouse's or partner's income.)
 - ☐ *\$0 - \$14,999*
 - ☐ *\$15,000 to \$34,999*
 - ☐ *\$35,000 to \$54,999*
 - ☐ *\$55,000 to \$74,999*
 - ☐ *\$75,000 or more*
 - ☐ *I don't know*
 - ☐ *I prefer not to answer*

Location	How frequently do you go?	If available, how often do you use handrails at the specific location?	How important is using handrails at the specific location?
1. Grocery stores ☐ I prefer not to answer	☐ Never (go to #2) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
2. Pharmacies ☐ I prefer not to answer	☐ Never (go to #3) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
3. Places of worship ☐ I prefer not to answer	☐ Never (go to #4) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
Location	How frequently do you go?	If available, how often do you use handrails at the specific location?	How important is using handrails at the specific location?
4. Restaurants ☐ I prefer not to answer	☐ Never (go to #5) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
5. Homes of family/friends ☐ I prefer not to answer	☐ Never (go to #6) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
6. Places where you work/volunteer/attend classes (choose the place where you spend the most time) ☐ I prefer not to answer	☐ Never (go to #7) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important

Location	How frequently do you go?	If available, how often do you use handrails at the specific location?	How important is using handrails at the specific location?
7.Large Stores ☐ <i>I prefer not to answer</i>	☐ Never (go to #8) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
8.Gas stations ☐ <i>I prefer not to answer</i>	☐ Never (go to #9) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
9. Doctors' offices ☐ <i>I prefer not to answer</i>	☐ Never (go to #10) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
Location	How frequently do you go?	If available, how often do you use handrails at the specific location?	How important is using handrails at the specific location?
10. Museums/ Landmarks ☐ <i>I prefer not to answer</i>	☐ Never (go to #11) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
11.Public parks ☐ <i>I prefer not to answer</i>	☐ Never (go to #12) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
12. Exercise facilities ☐ <i>I prefer not to answer</i>	☐ Never (go to #13) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important

Location	How frequently do you go?	If available, how often do you use handrails at the specific location?	How important is using handrails at the specific location?
13.Sports arenas ☐ <i>I prefer not to answer</i>	☐ Never (go to #14) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
14. Movie theaters ☐ <i>I prefer not to answer</i>	☐ Never (go to #15) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
15. Shopping malls ☐ <i>I prefer not to answer</i>	☐ Never (go to #16) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
Location	How frequently do you go?	If available, how often do you use handrails at the specific location?	How important is using handrails at the specific location?
16.Beauty salons/Barber shops ☐ <i>I prefer not to answer</i>	☐ Never (go to #17) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
17. Durable Medical Equipment vendors/suppliers ☐ <i>I prefer not to answer</i>	☐ Never (go to #18) ☐ Yearly ☐ Monthly ☐ Weekly ☐ Daily	☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important
18. Your home ☐ <i>I prefer not to answer</i>		☐ Never ☐ Rarely ☐ Often ☐ Always	☐ Very unimportant ☐ Unimportant ☐ Important ☐ Very important

Handrail Use

The next group of questions will ask about your general use of handrails.

1. Handrail Use

1a. How often do you use handrails to guide you when going up stairs?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

1b. How often do you use handrails to guide you when going down stairs?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

1c. How often do you use handrails to guide you when going up ramps?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

1d. How often do you use handrails to guide you when going down ramps?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

2. Grasping for Balancing

2a. How often do you grasp handrails for balance when going up stairs?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

2b. How often do you grasp handrails for balance when going down stairs?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

2c. How often do you grasp handrails for balance when going up ramps?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

2d. How often do you grasp handrails for balance when going down ramps?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

3. Pulling (ascending) and Pushing (descending)

3a. How often do you use handrails for pulling when going up stairs?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

3b. How often do you use handrails for pushing when going down stairs?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

3c. How often do you use handrails for pulling when going up ramps?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

3d. How often do you use handrails for pushing when going down ramps?

☐ Never ☐ Rarely ☐ Often ☐ Always ☐ N/A

4. Safety

4a. How often do you use handrails for safety when going up stairs?

☐ *Never* ☐ *Rarely* ☐ *Often* ☐ *Always* ☐ *N/A*

4b. How often do you use handrails for safety when going down stairs?

☐ *Never* ☐ *Rarely* ☐ *Often* ☐ *Always* ☐ *N/A*

4c. How often do you use handrails for safety when going up ramps?

☐ *Never* ☐ *Rarely* ☐ *Often* ☐ *Always* ☐ *N/A*

4d. How often do you use handrails for safety when going down ramps?

☐ *Never* ☐ *Rarely* ☐ *Often* ☐ *Always* ☐ *N/A*

5.Characteristics

5a. How important is the aesthetic appeal of a handrail (how it looks) to you?

☐ *Very unimportant* ☐ *Unimportant* ☐ *Important* ☐ *Very important*

5b. How important is the texture of a handrail (how it feels) to you?

☐ *Very unimportant* ☐ *Unimportant* ☐ *Important* ☐ *Very important*

5c. How important is the height of a handrail to you?

☐ *Very unimportant* ☐ *Unimportant* ☐ *Important* ☐ *Very important*

5d. To grip a handrail, the shape is.....

☐ *Very unimportant* ☐ *Unimportant* ☐ *Important* ☐ *Very important*

Appendix B

Handrail Study Limitations

The pilot study was intended to address some fundamental issues on how people with mobility and visual impairments and limitations use different types of handrails. The study was limited by:

Small samples: No statistical comparisons could be made with total a total sample of 28 and group sample sizes of 6 to 8 participants. Sample sizes of at least 30 participants are needed to compare group differences. A power analysis could be made based on the differences found in the pilot study to estimate the group size needed.

Selection of impairment groups: The four groups of people tested in the pilot study are inadequate to represent the diversity of people living with disabilities. The heterogeneity for walking, balance, grip on handrails and seeing within each group was evident and requires a more restrictive set of inclusion and exclusion criteria for future studies. Some inclusion criteria might be developed using an operationally defined walking difficulty level, a grip strength test, vision test and balance assessment.

Selection of handrail types: Only three of many types of handrails were examined in the pilot study. Future work should include a greater variety of handrails.

Procedural issues: The number of stairs used in the test may need to be increased to get a better sample of stair climbing. Different ramp slopes may be related to changes in the use of handrails – steeper slopes may require more pulling and pushing. Having three sets of ramps and stairs would decrease the time taken to test the participants.

Survey improvements: The survey question on importance of handrails could be improved by changing the wording to clarify that the issue to be answered is the importance of having handrails at the different sites rather than the importance of use of handrails in those sites that have handrails which could be an added question.

Group discussions: The group discussions did not produce much information on handrail use or preferences. A specific set of questions for group discussions could be developed from the findings of the pilot study.

Videotaping improvements: Motion detection cameras could be used to provide a structure for analyzing different types of ascending and descending behaviors by study participants. Focusing on the grip used would provide useful information. Additional testing equipment that can measure the pressure placed on the handrails by the hands of participants would give better data on gripping differences used on each type of handrail.

Biographical Sketch – David B. Gray Ph.D.

Dr. David B. Gray is an Associate Professor of Neurology and Occupational Therapy at the Washington University School of Medicine in St. Louis, Missouri U.S.A. He teaches courses on disability policy. He is the principal investigator on several research projects on the participation of people with mobility impairments and on the environmental factors that influence participation (assistive technology and personal assistance). In partnership with Paraquad, a St. Louis Independent Living Center, his research group is developing objective measures to assess the barriers and facilitators to participation that are frequently found in the environment. He is the Director of the Enabling Mobility Center where people with mobility impairments and limitations are evaluated for the fit of their current assistive devices, tested for their skill in using their devices, exposed to alternative devices and trained in the use of their current or new devices. He has been active in developing the International Classification of Functioning, Disability and Health (ICF). He is a consultant to the Office on Disability at the US Department of Health and Human Services. He serves on the National Institute of Child Health and Human Development Advisory Council.

Dr. Gray was the Deputy Director of the National Center for Medical Rehabilitation Research (NCMRR) at the National Institutes of Health (NIH) from 1990 through 1995. At the NIH he helped to develop a national research program in the area of learning disabilities from 1981 – 1986 and 1988 - 1990. He was the author of the NIH supplemental research training grants, research fellowships for individuals with disabilities and the program announcement that resulted in the funding of 12 institutional rehabilitation research-training grants. From 1986 to 1987, Dr. Gray, a C5/6 quadriplegic, was the Director of the National Institute on Disability and Rehabilitation Research (NIDRR) at the U.S. Department of Education in Washington, DC.