Toilet Grab-Bar Preference and Center of Pressure Deviation During Toilet Transfers in Healthy Seniors, Seniors With Hip Replacements, and Seniors Having Suffered a Stroke.

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Abstract: Multiple toilet grab-bar configurations are required by people with a diverse spectrum of disability. The study purpose was to determine toilet grab-bar preference of healthy seniors, seniors with a hip replacement, and seniors post-stroke, and to determine the effect of each configuration on centre of pressure (COP) displacement during toilet transfers. METHODS: 14 healthy seniors, 7 ambulatory seniors with a hip replacement, and 8 ambulatory seniors post-stroke participated in the study. Toilet transfers were performed with no bars (NB), commode (C), two vertical bars (2VB), one vertical bar (1VB), a horizontal bar (H), two swing-away bars (S) and a diagonal bar (D). COP was measured using pressure sensitive floor mats. Participants rated the safety, ease of use, helpfulness, comfort and preference for installation. RESULTS: 2VB was most preferred and had the smallest COP deviation. Least preferred was H and NB. C caused largest COP displacement but had favourable ratings. DISCUSSION: The preference and safety of the 2VB should be considered in the design of accessible toilets and in accessibility construction guidelines. However these results need to be verified in non-ambulatory populations. C is frequently prescribed, but generates large COP deviation, suggesting it may present an increased risk of falls.

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Abstract

Multiple toilet grab-bar configurations are required by people with a diverse spectrum of disability. The study purpose was to determine toilet grab-bar preference of healthy seniors, seniors with a hip replacement, and seniors post-stroke, and to determine the effect of each hip replacement, and 8 ambulatory seniors post-stroke participated in the study. Toilet transfers were performed with no bars (NB), one vertical bar (1V), one horizontal bar (1H), two swing-away bars (S), and a diagonal bar (D) installed. RESULTS: 2V was most preferred and had the smallest COP deviation. Least preferred was NB and D. C and P bars created large COP deviation. DISCUSSION: Preference and safety of the 2V should be considered in the design of accessible toilets and in accessibility construction guidelines. However, these results need to be verified in non-ambulatory populations. CIs are frequently prescribed, but generate large COP deviation, suggesting they may present as increased risk of falls.

Keywords: assistive devices, workplace accommodations, high-risk fall patients, older care, stroke

Introduction

Using the toilet is a common and essential activity of independent living that can become a difficult and even potentially dangerous task in some populations. Aging results in degeneration of vestibular, visual, and musculoskeletal and neuromuscular systems, as well as cognitive capacity. These natural consequences of aging can significantly affect effective surgery (Norman-Taylor, Palmer, & Villar, 1998). However, of older adults who suffer from hip fracture and undergo a subsequent hip replacement, only 43% return to preoperative walking ability, and only 17% return to preoperative walking ability to perform activities of daily living (van Balm, et al., 2001). Dynamic balance is also reduced in individuals following hip replacement surgery (Naglewoski et al., 2003), and this, combined with reduced hip range of motion (Vogt, Breittmann, Pfeifer, & Baurack, 2003) and strength (Vize, Kranert, Rosenbeck, & Bourne, 1993) makes activities such as toilet transfers more difficult.

Another major cause of disability in older adults is cerebral vascular accidents, or strokes. Approximately 300,000 Canadians are currently living with the functional deficits of a stroke, which range from minor deficits to major disabilities which require long-term care. In fact, according to a report by the Public Health Agency of Canada (2009), 7.1% of Canadians aged 65 to 74 years old report living with a stroke, making it a very common cause of disability in older adults. Twelve to fourteen percent of strokes are pure motor strokes, but most strokes result in motor deficits ranging from decreased dexterity to quadriplegia, with the vast majority primarily affecting one side of the body (Arboux et al., 2001). Thus, most strokes result in difficulty performing normal motor tasks required for functional activities such as toilet transfers. In fact, in hospitalized stroke patients, 20% of the falls which they experienced occurred in the bathroom and during toileting, reinforcing the difficulty toilet transfers can cause in stroke patients (Turunma, van der Meulen, de Haan, van Straten, & Limburg, 1997).

Sitting down and standing up from the toilet are potential causes of falls in the elderly and those with physical disabilities (Oberti, 1983), and the installation of toilet grab bars have been suggested to prevent help falls in the elderly (Akyol, 2007). Furthermore, independence in toilet transfers is of major importance for maintaining autonomy. Bathroom aids such as toilet grab bars help to compensate for reduced physical capacity to allow for safer independent bathroom activities (Axtell & Yasuda, 1991), helping to prolong autonomy within the home.

Toilet grab bars are recognized as being essential for safe and successful toilet transfers in various populations, and thus there is legislation requiring their installation in public washrooms and public housing (e.g., Canada Standard Association (2004), Ministry of Municipal Affairs and Housing (2006)). The utility of toilet grab bars is also well established in occupational therapy and rehabilitation disciplines, and these assistive devices are frequently recommended for or provided for resident use by people with temporary or permanent physical disabilities. In order for the appropriateness of toilet grab bars to be code regulations and healthcare professional recommendations to be optimized, it is necessary to determine which grab bar configurations are best suited to support populations with a variety of physical impairments. It has been argued that current building code specifications concerning toilet grab bar configurations are primarily based on the needs of young physically disabled people, rather than older adults with physical limitations (Czaja, 1994; Faletti, 1984), and that newer designs directed towards frail elderly would not meet current accessibility requirements (Hurt, 1989). In task force N1-405 (1993) found that the toilet grab bar configuration preferred must by non-ambulatory older adults did not comply with either American or Canadian building codes. Aging is a dynamic process so it is essential that the toilet grab bar preferences of elderly preferences both with and without physical disabilities, as well as the configurations which allow for the greatest transfer stability, be assessed to determine that these guidelines can be improved if necessary. Both Sanford et al. (1995), and Delach, Buntik, Molindebroek, and de Bruijn (2007) have analyzed a variety of toilet grab bar configurations for prehensile and perceived safety in older adults. However, neither group looked specifically at older adults who had undergone hip replacement surgery or those who had suffered from a stroke. Furthermore, while the frequency of bar use (Sanford et al., 1995) and the location of hand placements on the bars during the toilet transfer (Dokker et al., 2007) were studied, the contribution of toilet grab bars on the control of center of pressure (COP) displacement on the floor during the sitting and standing procedures, an indication of postural steadiness (Prieto & Myklebust, 1993; Prieto, Myklebust, Hoffmann, Lovett, & Myklebust, 1996).

Santos, Delatine, Laviere, Plasmondon, & Imbeau, 2008), has not been studied. Increased COP displacement during standing has been associated with increased risk of falling (Cheng et al., 1998), making it a good measure to use in toilet transfers. This study is designed to assess the toilet transfer stability in ambulatory participants as opposed to those relying on wheelchairs. For the group being studied, COP displacement on the floor is an important measure of postural steadiness, whereas it may be less relevant in those transferring from a toilet to a wheelchair.

Thus, the purpose of this study was twofold. One purpose was to determine which toilet grab bar configurations are preferred by healthy older adults as well as older adults post-hip surgery or post-stroke. The second purpose was to determine how these various toilet grab bar configurations contributed to the stabilization of the anterior-posterior displacement of the center of pressure (A/P COP) as participants sat down onto and stood up from a toilet as an indicator of transfer stability.

Materials and Methods

Participants

Twenty-nine people divided into three groups participated in this study. There were 14 healthy older adults who had no physical impairments, had no joint replacements, and could perform toilet transfers without difficulty (OLDER ADULT: 7 males) aged 64.9 ± standard deviation of 5.0 years old, 7 older adults having undergone at least one hip replacement (HIP: 2 males) aged 73.4 ± 8.3 years old, and 8 older adults having had at least one stroke (STROKE: 6 males) aged 65.9 ± 9.4 years old. All participants were ambulatory. None of the OLDER ADULT group participants used walking aids, three of the HIP group participants used a cane, and all STROKE participants used either a cane or four-leg walker. All participants were recruited from Ottawa community centers, social programs, or the University of Ottawa.

Materials

A bathroom prototype was designed for this study, consisting of two standard height 17 in. toilets (American Standard, Musisagusa, ON, Canada). Placed directly in front of the toilets were two 25.4 cm x 10.1 cm pressure sensitive floor mats (Tact/Controls Inc, Victoria, BC), one for each right and left feet, which were positioned beside each other so that they extended lengthwise away from the front of the toilet. These pressure sensitive floor mats were connected to a computer via USB cable, and data were collected at 30 Hz using digital data acquisition software. In addition to the floor mats, six toilet grab-bar configurations were built around the two toilets: a comb (C), two vertical toilet grab-bars (2VB)—one bolted to the floor, and one fixed to the wall—one vertical bar (1VB), a horizontal toilet grab-bar (H) fixed to the left side wall, two swing-away toilet grab-bars (S) fixed to the rear wall, and a diagonal toilet grab-bar (D) fixed to the left wall. The toilet grab bars were bolted to the floor with M12 bolts. The 1VB, 2VB, D, and height of H configurations were positioned

Toilet Grab-Bar Preference and Center of Pressure Deviation During Toilet Transfers

977

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configuration removed from the repeated measures analysis for COP displacement.

**Results**

**Composite Ratings of Each Configuration**

In the OLDIER ADULTS, the D and 2V8 configurations were the only bars significantly higher than 1VB and S conditions, whereas all configurations including NB were rated significantly higher than H. In the HIP group, all bar configurations were rated higher than the NB condition except for H and D configurations. For STROKE, all bar configurations were rated significantly higher than NB, and 2V8 was the only configuration rated higher than H (see Figure 2).

**Ability to Successfully Use Each Configuration**

The OLDIER ADULTS group successfully completed both maneuvers with all configurations. In the HIP group, 2 participants could not perform the sit-and-stand task with the NB configuration, and one participant could not perform the sit-and-stand for each of the 1V, H, and D configurations. In the STROKE group, no participants could both sit-and-stand with all configurations. For the STROKE configuration, all participants could stand up, but 1 participant could not sit down. For both of the NB, 2V, 8A, and D configurations, 1 participant could not perform both maneuvers. Finally, 2 participants could not perform both maneuvers in the 1V configuration, and all but 3 participants could not sit down and stand up using the H configuration (refer to Table 1).

**A/P COP Displacement in Floor Mat**

Older adults. During the sitting task, the OLDIER ADULT group had significantly smaller A/P COP displacement in the 2VB than the C and H configurations. The D configuration had significantly smaller A/P COP displacements than the NB, C and H conditions. Interestingly, these differences were only apparent when comparing the COP displacements of the right leg, and no significant differences were found in the left leg.

During the standing, the OLDIER ADULTS had significantly smaller A/P COP displacement in all configurations except for C when compared to H. In addition, both the 2VB and D configurations had significantly smaller A/P COP displacements compared to the NB, C, and S configurations. Finally, the 1VB also had a smaller A/P COP displacement when compared to C. As with sitting, all significant findings only occurred in the right leg (see Figure 3).

**HIP**. In the sitting task, the HIP group demonstrated significantly larger A/P COP displacement in the C configuration than all configurations except for H and NB. 2VB also had a smaller A/P COP displacement than H and D, and 1VB also had a smaller A/P COP displacement than H. Most significant differences occurred in the unaffected limb, as this was likely the primary weight bearing limb, but the impaired leg also showed significant differences in the C and S configurations.

In the standing task, the HIP group demonstrated significantly lower A/P COP displacement in all configurations compared to the C configuration except for the NB configuration. The 2VB also had a smaller A/P COP displacement than H, 1VB, and D, which also had a smaller A/P COP displacement than H. Most significant differences occurred in the unaffected limb except for the C configuration (see Figure 4).

**STROKE**. In the STROKE group for the sitting task, the NB configuration had significantly larger A/P COP displacement than all configurations except for C. All these differences were only found in the unaffected limb. No other significant differences were found.

In the standing task, the C configuration had significantly larger A/P COP displacement than 2VB, 1VB, and D configurations in the unaffected limb. 2VB also had a smaller A/P COP displacement than 1VB and NB in the impaired limb (see Figure 5).

![Fig. 2. Composite rating scores of each toilet grab-bar configuration in older adults, those who have undergone hip-replacement and those who have suffered from a stroke.](image-url)
Table 1. The percentage of each group who could successfully sit down and stand up from the toilet using each of the various grab-bar configurations.

<table>
<thead>
<tr>
<th>Group</th>
<th>No Bars</th>
<th>Commode</th>
<th>2 Vertical</th>
<th>Vertical</th>
<th>Horizontal</th>
<th>Swing Away</th>
<th>Diagonal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older Adults (n = 14)</td>
<td>Sit 100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Stand 100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Flip Replacement (n = 7)</td>
<td>Sit 100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Stand 100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Post-Stroke (n = 8)</td>
<td>Sit 87.5</td>
<td>87.5</td>
<td>87.5</td>
<td>75</td>
<td>37.5</td>
<td>87.5</td>
<td>87.5</td>
</tr>
<tr>
<td></td>
<td>Stand 87.5</td>
<td>100</td>
<td>87.5</td>
<td>75</td>
<td>37.5</td>
<td>87.5</td>
<td>87.5</td>
</tr>
</tbody>
</table>

Note: The percentages are bold font when not all participants from that group could sit or stand using the specified grab-bar configuration.

Fig. 3. The COP location and displacement in the A/P direction of both legs during sitting (A) and Standing (B) in older adults. "L" indicates the left leg, and "R" indicates the right leg. The Y axis is the absolute distance in cm from the front of the toilet in the A/P direction, increasing as it moves in the anterior direction (away from the toilet). The solid black bar is the averaged COP displacement in the A/P direction, with the grey line indicating standard deviation; + = Indicates that the A/P COP displacement is larger than the corresponding leg A/P COP displacement with the two vertical bars condition; α = Indicates that the A/P COP displacement is larger than the corresponding leg A/P COP displacement with the diagonal bar condition; β = Indicates that the A/P COP displacement is smaller than the corresponding leg A/P COP displacement with the horizontal bar condition; γ = Indicates that the A/P COP displacement is larger than the corresponding leg A/P COP displacement with the one vertical bar condition.

Fig. 4. The A/P COP location and displacement on the impaired (I) and unimpaired (U) side during sitting (A) and standing (B) in the HIP group. The Y axis is the absolute distance in cm from the front of the toilet in the A/P direction, increasing as it moves in the anterior direction (away from the toilet). The solid black bar is the averaged A/P COP movement, with the grey line indicating standard deviation; α = Indicates that the A/P COP displacement is larger than the corresponding leg A/P COP displacement with the two vertical bars condition; α = Indicates that the A/P COP displacement is larger than the corresponding leg A/P COP displacement with the diagonal bar condition; α = Indicates that the A/P COP displacement is larger than the corresponding leg A/P COP displacement with the commode condition; β = Indicates that the A/P COP displacement is larger than the corresponding leg A/P COP displacement with the one vertical bar condition.

Discussion
We recorded A/P COP data from three groups of older adults as they used seven different combinations of toilet grab bars as assistive devices during sitting onto and standing up from a toilet. In general, the groups preferred the configuration with two vertical bars (2VB), while the no bar (NB) and horizontal (H) configurations were identified as the least preferred. Although there were slight differences between groups, the two vertical bar (2VB) configuration resulted in consistently low amplitudes of A/P COP displacement for all groups and for both the sitting and standing task. In contrast, for all groups and both tasks, the commode (C) configuration was consistently identified with greater amplitudes of A/P COP displacement.

Limitations
Given the physical setup of the artificial bathroom, the H and D configurations were both wall mounted on a single wall, which posed a limitation for some participants in the STROKE and HIP groups, as the bar was located in their midline. However, this difficulty was often encountered in real-life situations, since most public bathrooms only offer grab-bars on one side. In a residential setting, an occupational therapy home assessment can help overcome this limitation by suggesting a more appropriate bar configuration for the specific bathroom design. It is also important to note that the position of the toilet grab-bars with each configuration also contributes to COP displacement and user ratings, and conclusions drawn about the orientation of the bar (horizontal, vertical, or diagonal) should also be interpreted in light of the bar's position relative to the toilet.

Bar Rating
Healthy older adults gave the 2VB and D bars the highest composite rating of safety, ease of use, helpfulness, preference for installment, and comfort of 21.75 (±2.47) and 21.96 (±3.97) out of a maximum of 25 (though not statistically significantly higher than all other configurations), and rated the H configuration the lowest with 14.05 (±5.14; see Figure 2). All configurations were rated significantly higher than the H configuration, with 1VB and S also being significantly lower than both 2VB and D configurations. Using a similar rating scale, Sanford et al. (1995) also found that the D configuration was rated highest in ambulatory older adults, with a short horizontal side bar having the worst rating. Because Sanford et al. did not test the 2VB configuration, the fact that they found the S configuration to be rated second highest was consistent with our results. Consistent with our 2VB results were the findings by Dekker et al., (2007) who reported that healthy older adults prefer vertical toilet grab bars for both sitting down and standing up from a toilet. The fact that the OLDER ADULTS rated the NB configuration the third highest may be accounted for by the stigma towards the use of physical aids in older adults (Aminzadeh & Edwards, 1998; Tinetti & Powell, 1993).

For the HIP group, the C, 2VB, 1VB, and S configurations were rated significantly higher than both H and NB configurations can achieve this same feature by using toilets with raised seats. Interestingly, even with the elevated seat and reduced joint torques required to transfer, C still had the greatest displacement of the COP.

Finally, due to limitations in the setup of the toilet area, the H bar did not extend as far forward as recommended in the Ontario guidelines. In addition, only 2 participants from the STROKE group could successfully use this configuration because it was only available on their affected side, so it was removed from the A/P COP displacement analysis.
configurations. The C, 2TV, and 1VB configurations were not assessed by Sanford et al. (1995), but apart from these three configurations, the composite bar rating scores were similar between our independently ambulatory hip replacement participants and those reported by Sanford.

The STROKE group rated the 2VB, D, and C configurations highest and the NB and H configurations the lowest, however, the only statistically significant findings were that all bars were rated above the NB configuration, and 2VB was also rated above H. Interestingly, the STROKE group preferred the D configuration over the S configuration, whereas the non-ambulatory group in the study by Sanford (1995) rated the S configuration the highest. One possible explanation for this difference was that in the Sanford protocol, participants were required to navigate their ambulatory device over to the toilet in order to make the transfer, making a swing away bar very convenient for maximiz ing space, whereas in the present study, all participants began the sit-and-stand protocol once already positioned in front of the toilet. This is also an important consideration for the horizontal bar on the wall behind the toilet, which is only useful in either helping support the person while they stand facing the toilet to urinate, or in transferring onto the toilet from a wheelchair (Macé & Léautet, 1974). It is not typically used when standing in front of the toilet preparing for sit-and-stand transfers. However, the non-ambulatory participants in the study by Sanford also rated the horizontal bar configuration most poorly, which is one of the most questioned abilities of the bar (Sanford et al., 1995).

Ability to Successfully Use Each Configuration

All participants in the OLDER ADULTS group could successfully sit and stand from all configurations. This was expected, given that these participants were healthy older adults, and none of them required assistive devices when toiletting at home.

In the HIP group, 2 of 7 participants could not sit or stand with the NB configuration, and 1 of 7 participants could not sit or stand with the 1VB, H, and D configurations. All participants could successfully sit and stand with the C, 2VB, and S configurations. It was only 2 participants who could not use all of the configurations. Both participants were near the mean age of the group, one male and one female. The male could not use any hip replacement. Both of these participants could not use the NB configuration. One could not use either the 1VB or the H, and the other could not use the D configuration. Interestingly, the one who could not use the D configuration was the only participant with a solitary right hip replacement, and the D bar was on the right side. While sitting or standing with the D configuration, the participant eccentrically or concentrically pulled themselves forward, and towards the center. When sitting or standing with a support bar which utilizes a pulling strategy, it is necessary to be able to generate the weight-bearing force with the remaining limb, which may account for this participant being the only participant in the HIP group not able to sit or stand with the D configuration. The other participant had a left hip replacement and could not use the left-sided H configuration or the 1VB configuration which was available on either the right or left side. In this situation, the side of the bar unlikely contributed to the inability to use it effectively. As mentioned, the 1VB was available on either side, thus the availability of the side of the bar did not contribute. As it is, the bar could not be used.

The bar ratings for the group of young and older participants. No information on changes in CQ. The NTV group rated the 2VB configuration as a function of age could be found. However, it was noted that older adults had decreased trunk angular velocity during sitting down, they took more time to compensate for this, especially to younger people, and that they showed decreased angular velocity during sitting down as compared to standing up (Mourey, Pozo, Reuland-Marcet, & Didier, 1999). However, it is uncertain how these differences would affect A/P COP displacement during sitting.

For OLDER ADULTS, it was interesting to note that almost all significant differences in the A/P COP displacement were found in the right leg. This may be explained by the fact that 80% of the participants in the OLDER ADULT group were right side dominant and thus likely relied more heavily on this leg during the task. This is also suggested by the slightly more posterior location of the COP on the right leg across most configurations which would also suggest more of a reliance on this leg for force generation. In this group, the two toilet grab-bar configurations with the smallest A/P COP for both sitting and standing were 2VB and D, suggesting that they would be the best configurations for facilitating balance during the toilet transfer in older adults. The largest A/P COP displacement during both sitting and standing was observed with the H and C configurations, suggesting that these were the configurations with the least helpful in limiting A/P COP displacement during toilet transfers in OLDER ADULTS.

For the HIP group, most significant differences were only found in the unpaired leg. Like with the dominant leg in the OLDER ADULT group, this was likely because the unpaired leg bore the majority of the patient's weight. In the HIP group, the 2VB configuration had the smallest A/P COP displacement during both sitting and standing, suggesting that it is the best configuration for helping to maintain balance during toilet transfers. The 1VB and D configurations also had a relatively small COP displacement during sitting and standing, suggesting that these were the best configurations for facilitating balance during toilet transfers. The results seem to suggest that bars which are needed to facilitate pulling during the sit-to-stand motion and to allow hands to slide down bars for stabilization during the stand-to-sit motion. It is also important to note that an unilateral pulling bar which needs to be positioned on the side of the unpaired limb in participants with unilateral hip replacements. This may partially explain the benefit of the bilateral 2VB configuration over the other configurations. Finally, in the STROKE group, significant differences in A/P COP displacement were found in both the impaired and unimpaired legs. However, differences in COP displacement were most clinically relevant in the unpaired limb, as it was primarily responsible for weight bearing. Consistent with this, the unpaired limb was positioned posterior to the impaired limb, which is consistent with reports from other studies (Roy et al., 2007) and is essential for generating the majority of force for sitting and standing tasks. In the STROKE group, the 2VB configuration had the smallest A/P COP displacement during both sitting and standing, and 1VB and D also had relatively small A/P COP displacement during standing. The configuration with the largest COP displacement during standing was the C configuration. The configuration with the largest COP displacement during sitting was the NB configuration, and the configuration with the largest COP displacement during sitting and standing was the C configuration. These configurations were also helpful for maintaining balance during toilet transfers. This is of some concern, given that comorbid conditions are frequently prescribed for people with limited range of motion and strength. A possible modification which may increase the safety of C would be to lengthen the arms of the commode so they extend forward beyond the edge of the toilet, allowing the additional arm support to be over the base of support during the transfer. However, the effectiveness of this modification would need to be studied. As with the HIP group, it is important to recognize the importance of the side of unilateral grab bars relative to the impaired side in hemiplegic strokes. However, this is a more complex relationship in STROKE participants as a result of the potential involvement of upper limbs in STROKE participants. This may also contribute to the added benefit of the 2VB configuration in toilet transfers in the STROKE group. The H configuration was not included in the COP analysis because only three participants could successfully use this bar because of it only being available on their hemiplegic side.

Conclusions

Overall, the least A/P COP displacement was consistently recorded by all groups when using the 2VB configuration followed by the 1VB, and S configurations in various orders. The standard A/P COP displacement was observed with the H configuration followed by the NB and H configurations. The effect of the bar configurations on balance seem to be reflected by the user of either configuration, with having one of the highest ratings amongst groups and the H rated amongst the lowest by all participants. Interestingly, the C configuration was rated highest for both the HIP and STROKE groups but only had one of the largest A/P COP displacements. The high rating may be a reflection of the patients' discomfort or that the highest ratings for both the HIP and STROKE groups bars were those with the greatest stability provided. This may be considered a significant improvement or benefit to the patient in the seated position. It is important to note that despite C being one of the most frequently prescribed toilet transfer assistive devices, and may be less safe than the other toilet grab bar configurations. Toilet transfer fall risk in C versus other toilet grab bar configurations should be further studied. Furthermore, given the convenience of stand successful toilet transfers, the gain in safety while positioning one side with support arms extending further forward should be considered and studied. Based on the results of this study, it seems that the 2VB configuration is the most helpful, and it should be considered for inclusion in building code and accessibility guidelines. However, it should also be noted that this configuration requires two vertical bars fixed to the floor or walls, and this may interfere with navigation to and from the toilet in people who use wheelchairs and other mobility aids. Further research should assess the impact of the 2VB configuration on toilet stall and bathroom navigation in people with
mobility aids, and its feasibility for implementation into building guidelines.

Another relevant observation was that there were differences between the OLDER ADULTS, HIP, and STROKE groups in toilet grab-bar preferences, and A/P COP displacement during toilet transfers. This information could be useful in designing accessible bathrooms or toilets for specific populations. It could also be useful when providing guidance to individuals who are planning on installing bathroom grab-bars in their homes, based on their specific physical disabilities. The favorable ratings and reduced A/P COP displacement during toilet transfers with the 2VB configuration in all groups should be taken into account in the construction of accessible toilet stalls and bathrooms, and should be considered in accessibility construction guidelines. Moreover, these data highlight the need for multiple design options for addressing the wide spectrum of needs in individuals with disabilities and in healthy elderly people.

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