The University of Sydney
Faculties of Health Sciences and Architecture
The Home Modification:
Information Clearinghouse Project

Evidence Based Research: Effectiveness of Grabrail Orientations during the Sit to Stand Transfer

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Abstract:

Objectives: Performing a sit to stand transfer is a prerequisite for many activities of daily living. However, this transfer has been defined as one of the most biomechanically difficult functional tasks, which only becomes more difficult as people age (Riley, Schenkman, Mann, & Hodge, 1991). To aid this transfer, particularly for older people performing a toilet sit to stand transfer, installation of a grabrail sometimes occurs. However, there remains much debate among therapists worldwide as to the correct positioning and orientation for grabrails (Cheung, 1997). This study aims to provide a comprehensive overview of the existing literature to identify the effects of grabrail orientation on the body and areas which require further research.

Design: To complete this research project a systematic review protocol was adopted. This is a rigorous process ensuring that all relevant and available literature on a given topic is located, reviewed and analysed. A specific search strategy was developed to ensure a comprehensive search of all data sources was completed. The data included in this review was obtained from a variety of sources including electronic databases, the World Wide Web and legislation and regulatory documents. A strict inclusion and exclusion criteria were developed to ensure only the most important and relevant information was included in this review.

Results: A total of 27 articles and 15 national and international legislation and regulatory documents were located and included in this systematic review. A majority of the research located was completed in the United States of America and Australia. Many of the articles were biomechanically oriented and focused on the older population, who more regularly use grabrails.

Conclusions: All of the articles included in this systematic review agreed that some form of arm support, be it grabrails or armrests, provided support to the body while performing a sit to stand transfer. However, no clear recommendations could be made on which orientation of grabrail assists the person without causing undue stress. From the results obtained specific biomechanical stresses were identified for each grabrail orientation. Despite these recommendations, further research is required in this area to develop improved guidelines for therapists, policy makers, home modification providers and consumers alike.

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Problem Statement:

Which grabrail orientation, horizontal or vertical, provides the best assistance to a healthy older person during a sit to stand toilet transfer?

Areas of Concern:

Installation of appropriate grabrails next to the toilet, reduction in secondary disabilities occurring through use of a grabrail.

Background:

Australia's population is ageing. By 2051 the projected percentage of our population over the age of 65 will be between 27% and 30% (Australian Bureau of Statistics, 2003). This will have risen from the current situation where older people comprise just under 13% of the population (Australian Bureau of Statistics, 2005). The increase in the older population is due primarily to an increased life expectancy in combination with a decreased fertility rate. Concurrent with the ageing process, bodily changes may affect an older person's functional performance such as mobility and self care.

For example, the ageing process has been linked to a generalised decrease in muscle strength and joint range of motion, especially at the hip, knee and spine, as well as difficulties with proprioception and balance which in turn affects performance during a sit to stand transfer (Alexander, Schultz, & Warwick, 1991; Millington, Myklebust, & Shambes, 1992). Additionally, older people typically experience a generalised slowing of many of the body systems including the nervous, sensory and cognitive systems (W. B. Carter, McKenna, Martin, & Andresen, 1989; McLean & Lord, 1996; Rice, 1986). As the nervous system overarches all other body systems, a person may become slower to react to sensory stimuli and as a result generalised slowing of motor responses and cognitive processes may be evident. Consequently the process of ageing affects how an older person manages a sit to stand transfer.

Sanford, Arch, & Megrew (1995) maintain that grabrail provision based on a thorough assessment of the person and their environment can provide the person with an increased sense of safety and greater independence. This is unsurprising given that environmental hazards have been found to be a contributing factor in most falls around the home, including in the bathroom and toilet (S. E. Carter, Campbell, Sanson-Fisher, Redman, & Gillespie, 1997). Typically during the home visit and/or functional assessment the hazards specific to the individual and their environment are identified and steps are then taken to reduce any hazards identified. Consequently it is fairly common for assistive devices such as grabrails to be recommended and installed in the bathroom (Clemson & Martin, 1996; Sonn & Grimby, 1994; Trickey, Maltais, Gosselin, & Robitaille, 1993). Thus grabrail prescription and installation, has the potential to minimise the effects that disability or old age have on the performance of the sit to stand transfer.

The primary purpose of the majority of grabrails installed in the bathroom and toilet is to assist a difficult transfer in a wet environment. Provision of grabrails at toilets are often seen as a prerequisite for safe and independent toileting, particularly in the older population (Sanford et al., 1995). Therefore it is essential that older people have access to correctly installed and positioned grabrails which will assist with the sit to stand transfer. Along with the high installation rate researchers have found that these assistive devices have a high usage and satisfaction rate (Aminzadeh & Edwards, 1998; Clemson & Martin, 1996; Edwards & Jones, 1998; Sonn & Grimby, 1994; Stark, 2004; Trickey et al., 1993).

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Regardless of the frequency of prescription of grabrails, many issues arise concerning positioning and orientation of the grabrail. Much of the research which has been completed focuses on the rate of prescription and rate of use rather than the specifics of orientation of the grabrail. In a study completed by Clemson and Martin (1996), who assessed one hundred and forty four older participants in regards to the use and effectiveness of rails in the bathroom and toilet, found that even though most people used the rails installed next to their toilets some were dissatisfied with the placement and orientation. However, little is known about how the use of each grabrail orientation affects the body during a sit to stand transfer.

The sit to stand transfer involves many specific and difficult movements, such as developing adequate torques at the knee and hip joints, in conjunction with coordination of spatial and temporal motion of the body segments (Bahrami, Riener, Jabedar-Maralani, & Schmidt, 2000). The successful completion of a sit to stand transfer also depends on the range of motion of the joints and the forces placed on the body. Through these movements the body's centre of mass moves from an intrinsically stable three point support during sitting to a dynamically stable two point support when standing (Bridge, 2003; Riley et al., 1991).

The way a sit to stand transfer is performed changes as a person ages. Many of these changes relate to a decrease in muscle strength, such as the development of adequate torques and controlling momentum (Alexander et al., 1991; Beissner, Collins, & Holmes, 2000; Trickey et al., 1993). Chair rise strategy also changes along with the time taken to rise successfully (Alexander et al., 1991). The consistency of the movements among the older population also decreases, which provides a signal to the changes that may be occurring throughout the transfer. To assist with this transfer grabrails may be prescribed. The effect that a grabrail and its orientation may have on the body has yet to be clearly defined. This paper aims to compare and collate all this information to provide a comprehensive outline of the effects of grabrail orientation on the body.

Evidence Based Practice Methodology:

A systematic review, guided by the *Protocol guidelines for systematic reviews of home modification information to inform best practice* (Bridge & Phibbs, 2003) developed by the Home Modification and Maintenance Information Clearinghouse was used to complete this study. This protocol was chosen as it has been developed using a home modification and occupational therapy perspective. The protocol focuses on the person-environment-activity fit to analyse and critique studies. In addition, this protocol is inclusive of all evidence levels; systematic reviews, randomised control trials, experimental studies, quasi-experimental studies, case control studies, legislation and regulatory documents, expert evidence and anecdotal evidence. The data sources included after an extensive searching process are subject to rigorous analysis to ascertain the reliability, validity and specific weighting of the findings to be included in the review. The methodology outlined ensures that transparent analysis and reporting of the results occur.

Search Terms:

Specific search terms were identified from the research question and comprehensive literature review which were used to search for appropriate material on electronic databases and the World Wide Web. Table 1 contains the search terms, including those that were truncated.

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Table 1: Search Terms

Environment	Person	Activity
Grabrail* Grab rail* Grab bar* Rail* Grab-rail* Handrail* Toilet Lavatory Bathroom Commode Horizontal Vertical	Older population* Older people* Aging Age* Elderly* Senior*	Sit to stand transfer* Sit to stand* Sitting to standing*

Databases Searched:

A wide variety of electronic databases were selected to ensure a comprehensive search was undertaken and all articles of relevance were located. A structured search strategy was developed which combined the above search terms. The following is a list of all areas searched.

- HM Info Library
- Ageline
- AMED (Allied and Complementary Medicine)
- AMI: Australasian Medical Index
- ARCH: Australian Architecture Database
- AVE: Avery Index to Architectural Periodicals
- CINAHL (Nursing and Allied Health)
- Compendex Plus
- Current Contents
- Dissertation abstracts
- Expanded Academic Index ASAP
- Medline
- OSH-ROM
- ProQuest 5000
- PsycINFO
- PubMed
- Science Direct
- University of Sydney Theses
- Web of Science
- WWW via the Google and Google Scholar Search engine
- Legislative and Regulatory Documents

Truncation symbols:

The following symbols are used throughout the electronic databases for truncation purposes. These symbols were used during the electronic database searches in this study.
*, $, ^ and ? (Use of each symbol varies depending on database).

Operators:

The following are operators used in the electronic databases to expand or limit the search. AND, OR, NOT, WITH, NEAR, IN, ADJ, ADJn, FREQ, SAME, W/nn, NOT W/nn, PRE/nn, W/SEG, =, @, %, !

Inclusion and Exclusion Criteria:

Specific inclusion and exclusion criteria were developed to ensure only the most relevant articles were included in the review. Material was included if it was (a) accessible through the

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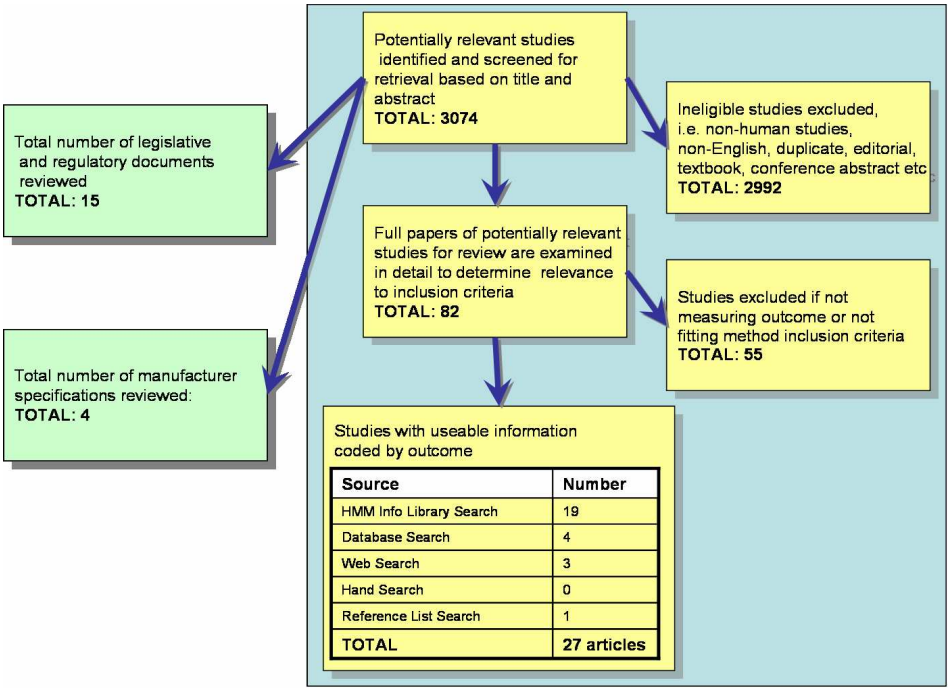
University of Sydney Library network or the World Wide Web, (b) written in English, (c) a human study and (d) printed after 1950 due to the changes in the home modification industry and the understanding of biomechanics. Materials which did not meet the inclusion criteria or were whole of subject books, editorials or conference papers were not included in the review. Figure 1 illustrates the search process and the final number of articles included in this study.



Source	Number
HMM Info Library Search	19
Database Search	4
Web Search	3
Hand Search	0
Reference List Search	1
TOTAL	27 articles

Figure 1: Search process and number of articles included during searching

Results:

General Outcomes:

The material included in this study was located from the HMinfo Library, Ageline, AMED and AMI databases as well as the World Wide Web. This study reviewed twenty seven articles, fifteen legislation documents and four manufacturer specifications. The articles located covered a span of fifteen years, with the earliest article being published in 1990.

Nationality of Material:

The material collected originated from only five countries. The majority (47%) of the material was completed in the United States of America. Studies completed in Australia were the next largest group, making up 30% of the material. Canada had 15% of the material, with Hong Kong and Germany both producing 4% of the material. This information is presented in Figure 2.

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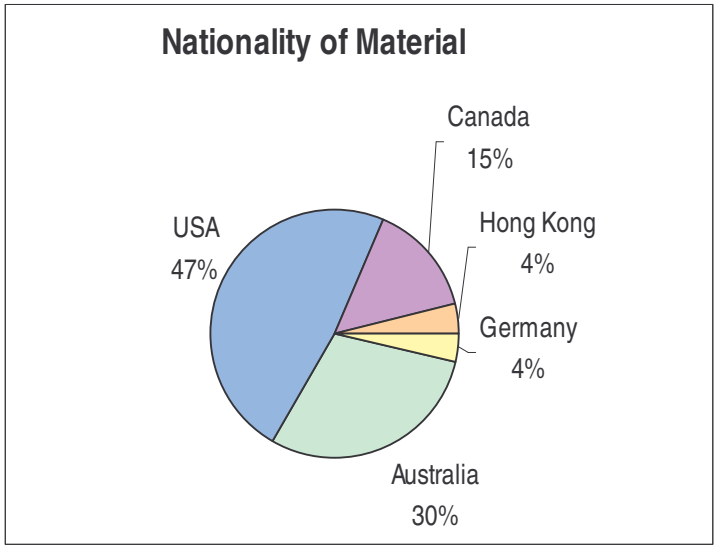

Figure 2: Nationality of material

Quality of Evidence:

Over half the studies included in this review were completed using a quasi-experimental methodology. This was the highest form of research evidence located. No systematic reviews or randomised control trials were located. Expert opinion comprised a third of the articles, with both case study and anecdotal evidence each comprising 4% of the articles. Figure 3 illustrates the methodology types of the included articles.

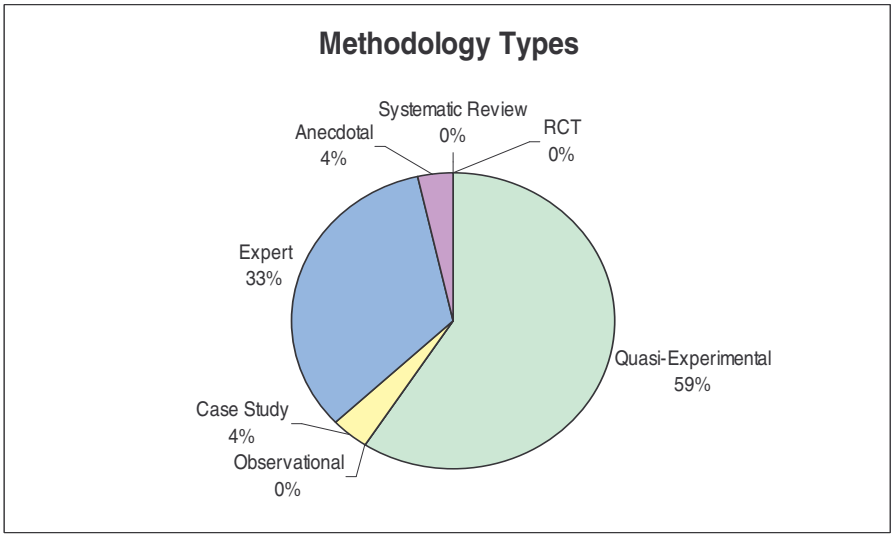

Figure 3: Methodology types

Analysis Outcomes:

The variables of each study were coded as person, environment and activity.

Person Variables:

The Person variables consisted of older healthy people and two comparison variables of older other, that is, older people with a disease or impairment, and people of all ages. The study variable of older healthy people was located in the included literature sixteen times. This was

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the majority of the Person variables (61.5%). The comparison variables of all ages and older other occurred seven and three times each respectively. These results are displayed as a bar graph in Figure 4.

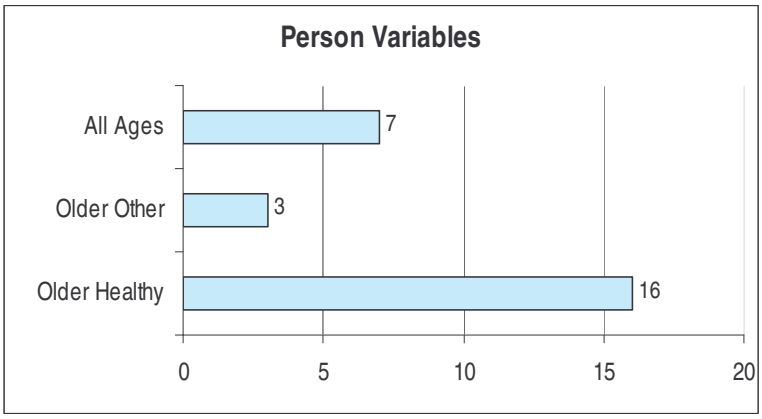

Figure 4: Person variables

Environment Variables:

Variables relating to the environment consisted of four different arm support situations. The two study variables of vertical grabrail and horizontal grabrail were complemented by comparison variables of grabrail other (other orientations) and chair armrests. Both vertical grabrail and horizontal grabrail were discussed thirteen times each in the included literature. However, they were not located in the same thirteen articles. Ten articles discussed both vertical and horizontal articles, three articles discussed vertical grabrails individually and three articles discussed horizontal grabrails individually. The armrest variables were located in five articles and grabrail other was discussed fourteen times. These results are represented in a bar graph in Figure 5.

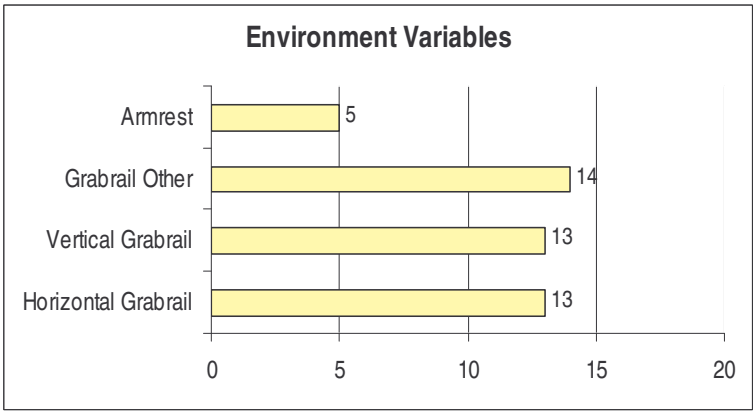

Figure 5: Environment variables

Activity Variables:

Activity variables included on the matrix form consisted of one study variable of sit-to-stand (STS) toilet transfer and two comparison variables of sit-to-stand transfer other and sit-to-stand transfer incidents. The sit-to-stand toilet transfer was discussed in fourteen studies. Sit-to-stand other (including from a chair) was discussed nine times; however, sit-to-stand incidents were not mentioned in any of the included studies. These results are represented in Figure 6 by a bar graph.

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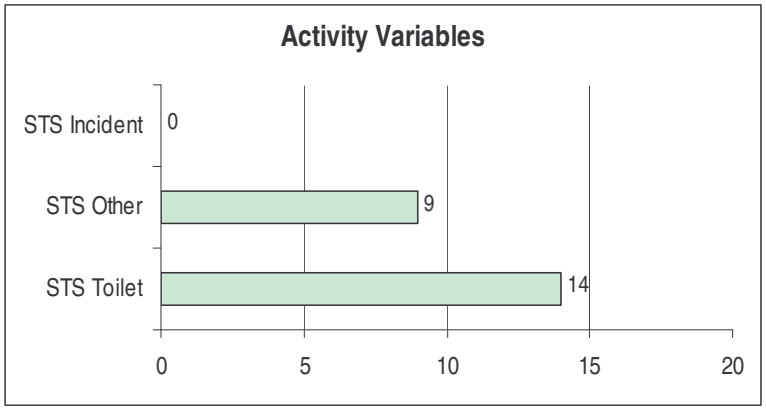

Figure 6: Activity variables

The information collected from the articles has provided valuable insight into how a grabrail and varying orientations may affect the body, particularly that of an older person, when being used to assist with the sit to stand transfer.

Legislation/Regulation relevant to grabrails in residential construction and retrofitting:

To ensure adequate coverage of the legislation regarding grabrail orientation, a search for both Australian and international documents was performed. The following outlines and provides a summary of the major documents accessed. The relevance of these documents to grabrail orientation, particularly next to the toilet, is noted.

A total of 15 documents were reviewed, with nearly half (seven documents) originating from Australia. Each document provided information on accessible buildings (both public and private) for all users. Fourteen documents outlined grabrail orientation and placement in relation to the toilet. However, a majority of these documents focused on public buildings and facilities rather than the private home, where many occupational therapists prescribe grabrails. Table 2 outlines the 15 documents relating to grabrail placement including date of publication, the focus population group and the buildings to which it applies.

Table 2: Introduction to Legislation and Regulatory Documents

Country	Document	Date Published	Population Group	Application to building types
Australia	Disability Discrimination Act (Attorney-General's Department, 1992)	1992	All people	Discusses the right of all people, regardless of disability the right to access to all public buildings
Australia Cont'd	Building Code of Australia	2004	General building access for all users	Class 3, 5, 6, 7, 8, 9, 9c and 10a. All these buildings are public facilities such as aged-care homes, shopping centres, hotels, cinemas, sport centres and boarding houses.

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Country	Document	Date Published	Population Group	Application to building types
	AS 1428.1 (Standards Australia, 2001)	2001	Wheelchair and ambulatory users	Class 3, 5, 6, 7, 8, 9, 9c and 10a. However, any building specifically designed for people with a disability can supersede these standards to ensure special needs of the occupant are met.
	AS 1428.2 (Standards Australia, 1992)	1992		
	DR 04019 (Standards Australia, 2004)	2004		
	AS 4226 (Standards Australia, 1994)	1994		All residential buildings, including private houses and apartments.
	AS 4299 (Standards Australia, 1995)	1995		
United States of America	ADA Standards for Accessible Design (Department of Justice, 1994)	1994	Wheelchair users only	Applicable to all new and renovated public buildings such as shopping centres, public accommodation and cinemas.
	ADAAG (Access Board, 2002)	2002		
	Minnesota Rules (Minnesota State Government, 2000)	2000	Wheelchair and ambulatory users	Applicable to boarding care homes and nursing homes.
United Kingdom	Approved Document M (Office of the Deputy Prime Minister, 2004)	2004	Wheelchair and ambulatory users	All new public buildings and dwellings as well as any new renovations or additions to these buildings.
	Code of Practice on Access and Mobility (Merseytravel and Merseyside Metropolitan Councils, 2003)	2003	Wheelchair and ambulatory users	Public buildings and areas only.
Northern Ireland	Building Regulations – Technical Booklet R (Department of Finance and Personnel, 2000)	2000	Wheelchair and ambulatory users	Public buildings and facilities where disabled people may be visitors or work in the building.
Singapore	Sanitary Provisions (Disabled Persons Association Singapore, 1995)	1995	Wheelchair users only	Public buildings and facilities including hotels, aged-care facilities and shopping centres.
Philippines	Accessibility Law (Republic of the Philippines Government, 1997)	1997	Wheelchair users only	All buildings and facilities for public use.

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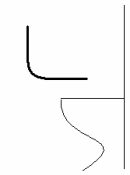
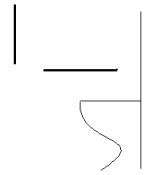
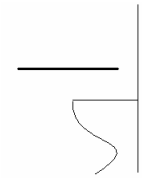
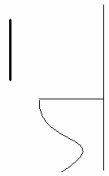
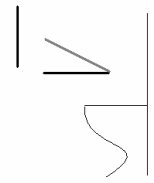
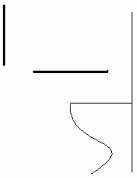
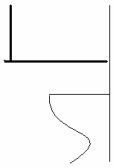
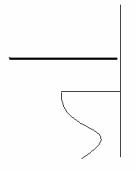
The above documents each provide varying recommendations and requirements for the installation of grabrails. Table 3 provides an overview of the orientations required from each country.

Table 3: Recommended Grabrail Orientations from Legislation and Regulatory Documents

Country/ Document	Recommended Grabrail Orientation	Country/ Document	Recommended Grabrail Orientation
Australia – Building Code of Australia and Australian Standards		Northern Ireland – Building Regulations	
USA – ADAAG		Minnesota (USA) – Minnesota Rules	
United Kingdom – Approved Document M		United Kingdom – Code of Practice on Access and Mobility	
Singapore – Sanitary Provisions		Philippines – Accessibility Law	

The differences between the requirements for grabrail orientation in each country are quite substantial. For example, the Australian requirements have a multidirectional grabrail with both horizontal and vertical orientations, whereas the USA require a single horizontal grabrail. An understanding of why these differences occur is not readily apparent. The data guiding the standards and the research available when each standard was being developed may contribute to such differences. However, due to limits in the research, it is unclear as to whether research or expert opinion leads many of the recommendations.

Legislation documents provide therapists, policy-makers and consumers with a benchmark to prescribe grabrails. However, with such great differences between the requirements between countries, grabrail prescription is different in each country. Therapists, therefore, are providing people who have similar requirements with different grabrail orientations, without fully understanding the effects different orientations may have on the body. Therefore, when answering the focus questions, legislation was compared with the research located to determine the orientation providing the best assistance.

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Focus Questions:

Does grabrail orientation have an effect on the body of an older person when performing sit-to-stand transfers? If so, how?

In short, the answer to this question is yes. Grabrail orientation can have a profound affect on the body of an older person. Men and women have individual anthropometric dimensions, such as height, along with different requirements (Bridge, 2003). Because of these differences a single grabrail orientation provides a different level of assistance to each person. However, it has been found that orientation can influence the mechanics of a sit-to-stand transfer for able-bodied people (O'Meara & Smith, 2005). The grabrail orientation may have an affect on the body, including changes in peak joint angles, range of motion, forces and torques. It is necessary to remember that not all people will experience all changes, and the changes experienced are in varying degrees.

How does grabrail use and orientation affect the sit-to-stand transfer?

The functional performance of an older person during the sit-to-stand transfer is improved when using a grabrail. Areas such as the stages of the transfer, rise speed, stability and falls can all be affected by the use of a grabrail. In most cases this effect is positive and assists an older person to successfully complete the transfer. However, some changes may not provide the best assistance to the user and can impact on the way s/he can complete the transfer by increasing the amount of strength and energy required.

Are there any contra-indications for older people for the use of horizontal grabrails?

The horizontal grabrail is recommended by most legislation requirements and was discussed by all manufacturer specifications received. In addition, this orientation was prescribed more regularly by occupational therapists than the vertical grabrail in the study by Cheung (1997). This highlights the frequency with which the horizontal grabrail is prescribed. However, there has been research published discussing how the horizontal grabrail may not be the most appropriate orientation for all users. Generally speaking, a grabrail placed to the side of the toilet is not appropriate for users with one-sided impairments, for example a stroke, if the grabrail is placed on the same side as the impairment (O'Meara & Smith, 2005). O'Meara and Smith (2005) discuss the use of a grabrail placed in front of the toilet to combat this problem. However, this may not be appropriate due to the environment. A grabrail in this position may also become a hazard in the environment. This is why grabrails placed to the side of the toilet are most commonly installed.

The horizontal grabrail has been shown to be less effective in providing assistance during the sit-to-stand transfer compared to other grabrail orientations (Maben, 2003; O'Meara, 2003). Maben (2003) has even gone as far as to claim the horizontal grabrail is "essentially useless" (p. 26). The ability to move the hand up vertical and angled grabrails can increase transfer independence in all stages of the transfer (Maben, 2003). In addition, larger forces and more kinetic and kinematic outcomes have been noted to occur during horizontal grabrail use, compared to other orientations (O'Meara, 2003).

Are there any contra-indications for older people for the use of vertical grabrails?

The vertical grabrail has only been recommended by a small number of the legislation documents. Little information has been published on this orientation and the effects that it has

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on the body. A select few theses have covered this subject and have all been completed at the same university in Australia. All but one of these theses have remained unpublished (McDonald, 1997; O'Meara, 2003; Ongley, 1999; Roland, 1996).

As stated in the above focus question, a grabrail placed to the side of the toilet, be it vertical or horizontal, may not be appropriate for users with a one-sided impairment when the grabrail is positioned on the same side as the impairment (O'Meara & Smith, 2005). A vertical grabrail also does not provide assistance as a weight-bearer, particularly one on which the user can support his/her full forearm when completing the transfer (Roland, 1996). In addition, the vertical grabrail may be positioned too far away from the toilet seat. This, according to Koncelik (2003) uses the weaker pulling strength of the extended arm rather than the stronger downward push. However, this fact was not backed up with any scientific research and therefore must be considered with some caution (Koncelik, 2003).

Are the legislation requirements adequate for use by healthy, ambulatory older people?

The legislation requirements as discussed above, for grabrail placement and orientation, are used in most public buildings and are used as a guide for grabrail prescription and orientation in private dwellings. The research regarding grabrail orientation is incomplete, however, the legislation documents provide a basis for therapists to prescribe grabrails (Pauls, 1991). It is noted that the placement and orientation of the grabrail may make the rail useless (Koncelik, 2003). Therefore, the varying grabrail requirements from different countries may not necessarily provide the best assistance. There has been some research questioning the requirements of the legislation documents. Many of the legislation documents focus on the needs of wheelchair users in regards to grabrail orientation and placement. There is, however, no evidence to suggest the same accessibility standards intended to promote independent toileting in wheelchair users assist ambulatory older people (Sanford et al., 1995).

According to the literature, which orientation provides the best assistance to healthy older people?

Both horizontal and vertical grabrails provide assistance to an older person when performing a sit-to-stand transfer. However, both orientations can have a negative affect on the body. The joint torques, peak joint angles, range of motion and joint forces are all affected when using both orientations. The changes seen can have a positive effect on the body, therefore making the transfer easier to complete. However, negative effects also occur, impacting on co-morbidities, thus leading to secondary disabilities.

In general, for both grabrail orientations, the positioning can cause the grabrail to become more of a hazard than an assistance. A wall-mounted grabrail, depending on the wall stud positioning, may be placed too far away for a user to reach, therefore not providing adequate assistance to the user (Fernie, 2000). The placement, particularly of the vertical grabrail, can mean that even though it has been installed with the best intentions, it may become a hazard during the transfer. In addition to positioning, several factors must be considered when prescribing a grabrail to provide the best assistance to an older person. The following section discusses the considerations needed when installing a grabrail for an older ambulatory grabrail user.

Considerations for Grabrail Installation:

When prescribing a grabrail the most important issue that should be considered is the needs of

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the user and why a grabrail is required (Mann, Llanes, Justiss, & Tomita, 2004; Salmen, 1994). Each grabrail user has differing requirements, due to his/her individual anthropometric dimensions and any existing conditions or diseases affecting his/her functional performance of activities of daily living (Bridge, 2003). When prescribing a grabrail, careful matching of the position and orientation must be achieved in order to optimise the benefits of assistance provided (O'Meara, 2003). The placement of the grabrail can either provide the best possible assistance or can rule the grabrail useless (Koncelik, 2003). Therefore, an understanding of the user's functional ability and an awareness of how the environment affects the positioning of the grabrail is required. Both of these areas are discussed further in the following sections.

Functional Ability of Grabrail User:

A person's functional ability determines the grabrail orientation that provides the best assistance during the sit-to-stand transfer. The many biomechanical changes occurring with grabrail use determine whether the orientation is successful in providing assistance. Therefore, if a grabrail increases the stress around a damaged joint, the grabrail cannot reduce the biomechanical demands on the body to make the transfer easier and further damage to the joint could occur. Consequently, when prescribing a grabrail, the therapist must be aware of the impact that each grabrail orientation has on the body. Table 4 outlines the grabrail orientation most appropriate when there is a reduction in strength or joint integrity at the major joints involved in the transfer.

Table 4: Appropriate grabrail orientation for reduction in strength and joint integrity at major joints

Joint	Reduction in:	Which Grabrail Orientation?	Why?
Wrist	Strength	Vertical	Those people with limited strength cannot effectively use the ADAAG (horizontal) grabrails (Maben, 2003).
	Joint Integrity	Vertical	Greater range of motion is required at the distal joints of the arm when using a horizontal grabrail (O'Meara, 2003).
Elbow	Strength	Vertical/Horizontal	No specific research found relating to strength surrounding the elbow joint.
	Joint Integrity	Vertical	Larger range of motion required at the elbow joint when using a horizontal grabrail (O'Meara, 2003; Packer, Wyss, & Costigan, 1994).
Shoulder	Strength	Vertical	An increase in the required torques noted when using a horizontal grabrail (Schultz, Alexander, & Ashton-Miller, 1992).
	Joint Integrity	Horizontal	Greater range of motion found when using vertical grabrail, compared to the horizontal grabrail (O'Meara, 2003).

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Joint	Reduction in:	Which Grabrail Orientation?	Why?
Hip	Strength	Vertical	An increase in hip joint kinetics was noted when using a horizontal grabrail (O'Meara, 2003; O'Meara & Smith, 2005). The vertical grabrail decreases the compressive joint forces required (Ongley, 1999).
	Joint Integrity	Vertical/Horizontal	An increase in shear joint forces of the hip noted with vertical grabrail use (however, only found in one study) (Ongley, 1999). An increase in hip joint kinetics found when using a horizontal grabrail (O'Meara, 2003; O'Meara & Smith, 2005).
Knee	Strength	Horizontal	An increase in the required torques at the knee noted with vertical grabrail use (in one study only) (Roland, 1996).
	Joint Integrity	Horizontal/Vertical	A significant increase in the shear joint forces noted with vertical grabrail use (Bridge, 2003; McDonald, 1997; Ongley, 1999). However, a significant reduction in knee range of motion is also noted with vertical grabrail use (O'Meara, 2003; Ongley, 1999; Roland, 1996).
Ankle	Strength	Vertical/Horizontal	Torques at the ankle joint have been shown to increase with both horizontal and vertical grabrail use (Roland, 1996; Schultz et al., 1992). No comparative studies located, therefore no conclusion can be made about the orientation causing a larger increase.
	Joint Integrity	Horizontal	One study only found an increase in shear joint forces with vertical grabrail use (Ongley, 1999).

Environment:

When prescribing a grabrail, the environment can impact on the orientation and final positioning. The area where a grabrail is placed must be solid enough to support 1100 N of force in any direction (Standards Australia, 2001). Therefore, the stud positioning is important, or the use of specific screws to attach the grabrail to the wall will be necessary. If the stud placement is not in a suitable place for appropriate grabrail positioning the grabrail may become useless or unsafe (Pauls, 1991). The grabrail must be placed so it is close enough for the user to reach, but be far enough forward of the toilet to assist in the stabilisation stage. This is particularly pertinent for vertical grabrail placement. The height of the grabrail must also be considered. A common mistake when prescribing grabrails is placing the grabrail to low or too high (Pauls, 1991). The height of the horizontal grabrail must be more carefully considered than the vertical grabrail. A horizontal grabrail too low or too high does not provide the user with enough support to gain required momentum and postural stability during the earlier stages of

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the transfer. It has also been noted extensively that the horizontal grabrail does not provide adequate support during the final stabilisation stage of the transfer (Bridge, 2003; Sanford, 2001).

Future Research:

The objective of this research was to identify what is known and unknown about the assistance grabrail orientations provide to older people during a sit-to-stand transfer. This study has provided an overview of the current research and the large gaps in the existing research. The systematic review process provides a comprehensive way of identifying gaps in the existing research to highlight where further research is needed.

Research into the effects of grabrail orientations is lacking. The current evidence is limited, and many of the grabrail biomechanical studies have not been published for therapists, policy-makers and consumers to access easily. In addition, many studies use chair armrests in the studies rather than a grabrail. Therefore, more comprehensive studies need to be completed. The current research is based predominantly on quasi-experimental studies. Therefore, a randomised control trial will need to be completed to fully understand how a grabrail affects the healthy, ageing and disabled body to provide high-level evidence.

Only one biomechanical study comparing grabrail orientations was located during this study. This highlights a real need for biomechanical studies directly comparing grabrail orientations for different population groups. In addition, these studies should highlight the major stresses placed on the body during grabrail use. This will ensure that the most appropriate grabrail for each consumer can be prescribed without causing any secondary disabilities or co-morbidities. Limited studies have discussed the long-term use of a grabrail for an older person. Such studies will be important in determining the orientation providing adequate assistance for a person as s/he ages and as his/her circumstances change. By understanding the long-term assistance a grabrail can provide, further insight into the orientation providing the best possible assistance can be determined.

Information Strategies:

Develop a technical fact sheet on grabrail orientation for home modification and maintenance service providers, occupational therapists and builders.

Develop a plain English factsheet on advantages and limitations of grabrail orientations for consumers to encourage informed choice.

Policy Development:

The different national standards all have different recommendations for the most appropriate grabrail orientation. In addition, many of these documents assume that the grabrail requirements for wheelchair users is appropriate for ambulatory people, which has proven not to be the case. This highlights the need for the development of an international standard concentrating specifically on grabrail orientations for ambulatory users, such as older people. This study has highlighted the need for such a document and has provided the basis for further research to be conducted to develop a best-practice standard.

Conclusion:

The use of a grabrail to assist during a sit-to-stand transfer is common in many population groups, including the older population. Ensuring the best grabrail orientation is provided is

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important, due to the likelihood of a secondary disability occurring from use. To prevent a secondary disability occurring, the correct grabrail orientation for the user must be prescribed. This study has outlined the existing research into grabrail orientations, namely the horizontal and vertical grabrails. Both these grabrail orientations have positive and negative features when being used to assist with the sit-to-stand transfer. Therefore, no one orientation can be named as better than another. To ensure a client is provided with the best possible orientation, a therapist must take into consideration many factors, including any conditions the person may have and the environmental set-up. The results of this review are preliminary only, as the body of knowledge regarding grabrail orientations is limited. Further research will need to be completed to provide evidence for therapists, policy-makers and consumers alike to ensure sound evidence based practice can be achieved. Each grabrail installed should be matched with the needs and circumstances of each user.

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Acknowledgements:

This material was produced from the work undertaken by Hayley Seton whilst on placement at the HMinfo clearinghouse. Hayley's research thesis was supervised by Catherine Bridge and was originally published as an honours thesis.

The authors would also like to acknowledge the contribution of many experts both from the research review panel and from the grabrail industry who generously gave of their time, without them all sharing their ideas, perspectives and information this knowledge could not have been generated.

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