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## **Introduction**

**Why we felt stability best practice guideline were needed**

The static and dynamic stability of a wheelchair is critical to both its safety and its performance. An overly *unstable* wheelchair can result in avoidable injury or death from tipping, whereas an overly *stable* wheelchair can result in avoidable long-term use challenges, inefficiencies or abandonment. We have a responsibility to optimise stability for mobility, specific to the user needs.

Wheelchair providers commonly adjust wheelbases, seating elements or functions beyond typical usage expectations, as well as adding third-party accessories. Many of these changes affect the stability of the wheelchair system. Standards exist to guide manufacturers in their testing and governance, but providers are required to apply their own judgement in how to manage the risk and benefits of their adaptations.

Approaches vary across services in terms of *when* testing is carried out, *how* it is carried out, and what is done with the data, hence the need for best practice guidelines to consolidate and promote appropriate risk-benefit analysis for stability.

## **Target audience**

- Prescribers/handling over (wheelchair, seating, wheelchair accessories, wheelchair mounted devices)
- School staff
- End users
- Families and carers
- Manufacturers
- Transport providers
- Other healthcare providers

## **Common myths/misconceptions**

*“Wheelchair instability doesn’t cause problems these days”*

Stability incidents do still occur, although they may be sliding related rather than tipping related. It's also likely these are largely unreported to agencies such as MHRA.

*"A stability test pass means the wheelchair is safe"*

There is no pass / fail criteria. The test is designed to facilitate knowledge as part of the overall prescription and risk management

*"Wheelchair service REs are solely responsible for stability"*

Not necessarily. Any professional involved with wheelchair prescription has a responsibility to ensure the stability of the wheelchair is appropriate for the use within the specified environment.

*"More stable is always better"*

This will depend on how the wheelchair is being used. As an example a manual wheelchair user climbing a kerb might want the wheelchair to be more "tippy" to make it easier, as well as being more energy efficient, and probably safer.

*"Stability testing is only needed for special seating"*

Stability testing can be applicable to any situation, regardless of seating, and the attachment of other devices also has an influence, such as with communication aids or oxygen cylinders.

## **History and who is doing what test methods**

### **Current testing methods**

- Manual tilting (on a level floor)
- Static angle ramp
- Adjustable/variable angle ramp
- Force plates
- Environmental testing

Table 1 - List of services and the testing systems they employ for stability testing

Table 1 - List of services and the testing systems they employ for stability testing

This data has been extracted from a National Stability Testing questionnaire conducted in 2023, of which 16 responded from around the UK. Responses received from NHS services/Trusts, private wheelchair providers and wheelchair manufacturers.

The data below is the responses from the question 'What equipment do you use for stability testing?'

Testing Method	Number of Services/Trusts
<b>Static ramp</b>	5
<b>Load cells</b>	4
<b>Multiple/Additional methods</b>	3
Static ramp and clinician observation	1
Load cells and real environment	1
Static ramp and Load cells	1
Total	12
Testing Method	Manufacturers
Static ramp	2
Tilting ramp (adjustable)	1
Multiple/Additional Methods	
Static ramp, load cells and dynamic testing	1
Total	4

## What is stability, stability testing, evaluation

# **Dynamic versus static stability**

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## **Real life use of equipment**

Personal items and/or unexpected medical items attached on the back or sides of the wheelchair.

Outdoor environment

- Paving stones
- Cambered pavements
- Kerbs
- Dropped kerbs
- Tactile/ blistered paving
- Obstacles / Drain covers/ gutters / pot-holes etc
- Road inclines

Accessing vehicles – in and out using ramps

Accessing buildings – in and out

## **Stability and the effect on sliding and traction**

Environmental sliding (e.g. in a bus)

Environmental traction (e.g. delivering power through the wheels)

Point of sliding when doing stability testing on a slope

## **The relationship between wheelchair structure and stability, and the consideration of a chair's inherent stability**

Wheelchairs are not solid objects but are made from a number of individual components. There is a two-way relationship between how a wheelchair is constructed and stability; many wheelchairs allow for different positions of things such as the seat, backrest, footplates, armrests, etc – all of these can impact on the overall stability of the wheelchair by altering the centre of gravity of the wheelchair.

A similar thing can be said for stability of components within a wheelchair; where the seating is interfaced to the wheelchair base using a very narrow interface it will experience significantly higher torques around that interface than one which has a wider interface as it is inherently less stable. This can mean that there is the potential for increased damage to the interface either as the user moves within the seating, or as the chair moves through the environment.

The movement of the wheelchair user within the wheelchair is covered elsewhere in this document but it is important to remember that this is not the only source of variability within the wheelchair system as there can be movement of wheelchair components which may either increase or decrease the stability of the wheelchair and user.

A soft seat cushion, poorly fitted laterals or a loose interface on a seating system may all contribute to increased variability of the centre of gravity.

This in turn can lead to a feedback loop as the wheelchair system approaches what could be considered its limits of stability as movements of components or the user introduces extra uncertainty when trying to consider the dynamic stability of the system.

Care should therefore be taken with the internal components and construction of any wheelchair to align with the goals of provision.

## **Criteria for testing**

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## **What to do with data produced**

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## **Testing equipment and methodologies**

### **Fixed ramp**

Protocol

Improvisation on a known available slope

Limitations (e.g. manual handling risks; unsettling for occupant; only pass/fail no indication of by how much)

Best for (e.g. low equipment cost; works on 5 and 6 wheeled chairs)

### **Adjustable ramp**

Adjustable or variable ramps are ramps where the angle of slope can be altered.

#### **Protocol**

Methods used to achieve this, including but not limited to; a winch or jack, varied



size and/or geometry blocks, or an inflatable bag acting on a hinged slope.

Some adjustable or variable ramp systems are able to have the angle of slope altered while the wheelchair system remains in place on the ramp; this can reduce the number of manual handling events but does require appropriate safety features and measures to be in place.

## **Limitations**

- May be larger/heavier than a fixed ramp due to additional components
- May be more prone to breaking/damage due to adjustable mechanism
- Heavier to move for manual handling
- Unsettling for occupant
- Maximum user weight
- Need to prevent castor rotation

## **Electronic force plates**

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## **Manual tip test**

Manually tipping can give a broad sense of rearward stability of a wheelchair – typically for manual chairs only.

### **Protocol - attendant tipped**

It is completed by pushing down on the push handles to allow a sense of where the tipping point is, usually unbraked.

Due to the inter-assessor variability, the tip test cannot provide quantifiable results, but can identify whether further testing is necessary without any equipment.

As no equipment is required, it is a quick test to carry out in the community as well

as clinic, and can be used to quickly compare set up changes.

## **Protocol - user tipped**

Active users can tip themselves onto their rear wheels to assess their stability. They are much more likely to favour an 'unstable' set up, particularly in the rearwards position as this is helpful for function.

Risk can be minimised in this instance by standing behind the user should they become unbalanced or using a strap to prevent completely tipping over.

## **Limitations**

Although a useful test when no equipment is available, it is not possible to definitively determine whether a chair is stable enough to be safe. Further limitations also include:

- Manual handling risks to the assessor
- Risk of user injury
- Only possible for 4 wheels

## **What affects a wheelchairs stability/ benefits versus risks**

### **Impact of seating functions**

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# **Adapting wheelchair with accessories and other fitted third party items and medical devices**

## **Method for influencing stability and mobility**

Stability is dependent on where the centre of gravity acts over the wheelchair's areas of contact with the floor. Once the centre of mass is acting outside these areas of contact, the chair becomes unstable and is at risk of tipping.

Thus, the main components which are most likely to affect stability include:

The distribution of contact points relative to the centre of gravity

- How many wheels does the chair have, and which are the drive wheels?
- Do the wheels have any camber?
- Is the wheelbase particularly short or narrow?
- Is the seating positioned high up rather than low down, or far forward/rearward?
- Are any 3<sup>rd</sup> party devices fitted to the chair?

Any changes to the configuration of the chair which will alter the centre of gravity or the distribution of contact points, such as typical changes from the use of fixed tilt or tilt-in-space, backrest recline, leg rest elevation, and seat riser. The use of external components such as trike wheels, powerpacks; particularly those which apply a driving force to the chair.

## **Methods for increasing wheelchair stability**

Could be useful for passive users, those with involuntary movements, or where frequently navigating inclines/uneven terrain:

- Lower centre of gravity –
  - Minimal seat to ground height
  - Choosing a heavier base, even considering provision of an attendant powered chair in extreme circumstances

- Positioning carried medical equipment (e.g. oxygen cylinder) to avoid or offset instability
- Widen points of contact. This could be by increasing wheelbase width or length, or from camber of wheels
- Anti-tippers (forwards and rearwards)
- Caster outriggers
- In regard to tilt-in-space wheelchairs/buggies, choosing one using 'floating' pivots rather than fixed

## **Methods for decreasing wheelchair stability**

Could be useful for active users, particularly in the rearwards direction, or where attendants are having difficulty pushing

- Reduce rearward stability by moving casters and rear wheels closer together (forwards to back)
- Moving the combined CoG of the person and any seating backward relative to the rear axle
- Reduce overall weight of chair, noting that a lightweight chair set up poorly can feel heavier to push than a heavier chair set up well

## **Movement of the wheelchair user**

- The posture or build (including characteristics such as amputations) of the user which may impact where the centre of gravity sits
- The user propelling the chair
- The movement of the user during the normal operation of the wheelchair, including any involuntary movements

Any issues related to the control of the chair such as only being able to make gross movements

- Leaning over the base of the wheelchair, especially if lifting any additional weight. Wheelchair users with the ability to control their body positions can profoundly affect the stability of their wheelchairs
- Method of transfer
- Improper use of chair – for example sitting over front edge of the seat

## **Problem of optimal stability**

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## **Conclusions**

### **Risk management methodology to consider the holistic system**

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## **Developments in progress**

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## **Recommendations for future work**

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## **Stability assessment checklist**

Please note that these are suggestions of considerations related to stability and not an exhaustive list, nor should they substitute for clinical reasoning. Space is left to add considerations in each section should you wish to use this as a template.

**Have I assessed the users' needs adequately?**

**Yes No**

Will stability of the wheelchair need to consider:	Activities of daily living	<input type="checkbox"/>	<input type="checkbox"/>
	Environments of use	<input type="checkbox"/>	<input type="checkbox"/>
	Method of propulsion	<input type="checkbox"/>	<input type="checkbox"/>
	Position of seating or other wheelchair components	<input type="checkbox"/>	<input type="checkbox"/>
	Posture	<input type="checkbox"/>	<input type="checkbox"/>
	Transfers	<input type="checkbox"/>	<input type="checkbox"/>
	Users' additional equipment needs	<input type="checkbox"/>	<input type="checkbox"/>
	Users' goals	<input type="checkbox"/>	<input type="checkbox"/>
	Users' level of function	<input type="checkbox"/>	<input type="checkbox"/>
	Users' uncontrolled movement	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>

**Comments and clinical reasoning:**

<b>Do I need to evaluate the wheelchair stability?</b>		<b>Yes</b>	<b>No</b>
To meet the needs identified, does the wheelchair need to have at least one aspect be particularly:	Stable	<input type="checkbox"/>	<input type="checkbox"/>
	Unstable	<input type="checkbox"/>	<input type="checkbox"/>
Is the wheelchair likely to be used in a fashion where it is likely to be close to or beyond the limits of stability?	Consider this in relation to the needs identified (eg an active user is likely to deliberately make use of wheelchair instability, a user who has lots of additional equipment needs may have this stored in a way which increases the instability of the wheelchair system, etc)	<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>
		<input type="checkbox"/>	<input type="checkbox"/>

**Comments and clinical**

**reasoning:**

**Have I chosen the right evaluation method?**

**Yes No**

Does the evaluation method give me the right level of accuracy? If you only need an indicator that equipment will be stable in a flat, indoor environment without any significant instability factors you may only need a very low accuracy assessment, compared with tuning an active user chair which may require a more accurate assessment.

☐ ☐

☐ ☐  
☐ ☐  
☐ ☐  
☐ ☐  
☐ ☐

**Comments and  
clinical  
reasoning:**

**What do the results of the evaluation mean for this user?**

**Yes No**

To meet the needs identified, the wheelchair is too: Stable Unstable

☐ ☐

☐ ☐

Can I give specific recommendations to the user about the risks and safe use of the equipment?

☐ ☐

☐ ☐

☐ ☐

☐ ☐

☐ ☐

☐ ☐

**Comments and  
clinical  
reasoning:**

**Have I documented the risks and benefits?**

**Yes No**

☐ ☐

**Comments and  
clinical  
reasoning:**

**Have I conveyed, in a useful way, advice to the user?**

About specific use cases (eg transfers, using ramps, etc)

How to get the most out of their equipment

Specific risks to be aware of

**Yes No**

☐ ☐

☐ ☐

☐ ☐

☐ ☐

☐ ☐

**Comments and  
clinical  
reasoning:**