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Document summary

Posture and Mobility Group

The Posture and Mobility Group (PMG) is a membership organisation and Charitable Incorporated Organisation (CIO) which has the aim of sharing knowledge and promoting best practice in the field of posture and wheeled mobility. Currently, there are over 2000 members, mainly based in the UK, the majority of whom are professionals working in rehabilitation, focusing on the provision of wheelchairs and special seating.

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Introduction

Why we felt stability best practice guidelines were needed

The static and dynamic stability of a wheelchair is critical to both its safety and its performance. An overly *un*stable 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.

There is often a conflict between these two requirements, so a balance must be struck through careful and open-minded evaluation.

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.

Despite there being several methods to test stability, the ‘simple’ numerical output of such a test (typically an angle between 5° and 20°) often leaves us with more questions: What do we do with the number? How do we relate this to the person? Crucially, how do we communicate something meaningful to both the user and assessor?

The intent of this guidance is to improve clinicians’ awareness of stability evaluations by sharing variation in practice across the United Kingdom. The clinicians producing this document are volunteers. This document is not intended to be a comprehensive review of stability evaluation. It is offered in a spirit of curiosity and experience sharing rather than that of blame and fault finding.

Target audience

- Prescribers handing over equipment (wheelchairs, seating, wheelchair accessories, wheelchair- mounted devices)
- School staff
- End users
- Families and carers
- Healthcare professionals, e.g. community physiotherapists and occupational therapists
- Manufacturers
- Transport providers
- Other health and social care providers

Using this best practice guide

This best practice guide is intended to be accessible for both lay and professional audiences. To aid the reader, colour coding is used to help identify the nature of the information being presented in each section of the document.

When reading this document, it is important to remember that wheelchair stability is not a one-size-fits-all topic, and there may be scenarios, equipment setups, or user requirements which need to be discussed separately. Attempts have been made to indicate where this is the case and, where possible, to discuss those specific cases within their own sections of the document.

Glossary of terms

Term	Meaning
Active user / energy efficient manual wheelchair	A type of manual wheelchair used by people who lead an active lifestyle and can propel themselves. These wheelchairs require good trunk stability and upper body strength, and are intentionally less stable for manoeuvrability.
Anterior	Towards the front.
Back wheel balance	In an active user chair, the user intentionally tips the wheelchair onto its rear wheels, lifting the castors from the ground. This is often used to navigate a high edge such as a kerb.
Base of support	The points of contact between the wheelchair and the ground (or other surface supporting the wheelchair) through which the weight of the wheelchair acts.
Blocked	Refers to a stability test where the drive wheels are blocked to prevent the wheelchair from rolling and the tipping occurs around the pivot point of the wheel axle.
Braked	Refers to a stability test where the drive wheels are braked and therefore the tipping occurs around the pivot point where the wheel is in contact with the surface.
Centre of gravity (CoG) / Centre of mass (CoM)	The centre of gravity, or centre of mass, of an object is the point through which its weight can be considered to act. If the CoG is acting outside the base of support, the chair will become unstable and be at risk of tipping while the further inside the base of support it acts the more stable the chair will be.
Cross-slope	Positional description of a wheelchair / buggy on a stability testing ramp; the user is facing across the incline of the testing ramp; “left” or “right” describe the direction faced by the user relative to “up-slope”.
Also “Cross-slope left”, “Cross-slope right”	
Down-slope	Positional description of a wheelchair / buggy on stability testing ramp; the user is facing down the incline of the testing ramp.
Drive wheel	The wheel through which power is applied in order to move the wheelchair, either through a motor or human effort (i.e., self-propulsion)
Manual wheelchair	A wheelchair which is propelled primarily through the

	use of human force.
Posterior	Towards the rear.
Powered wheelchair / power chair	A wheelchair which is driven primarily by electric motors. Typically, these will be rear wheel driven (RWD), mid-wheel driven (MWD), or front wheel driven (FWD), according to where the drive wheel is located.
Recline	The angle of the backrest relative to the seat. It is generally described as the angle from the backrest being perpendicular to the seat. This will typically be either fixed or adjustable; fixed backrests tend to have between 0-10°, while adjustable backrests tend to allow between 0-50° of recline.
Tilt	The position of the seat relative to the wheelchair frame. The amount of tilt is generally described as the angle from the seat being parallel to the wheelchair frame. Negative angles are used to denote anterior tilt, while positive angles are used to denote posterior tilt, the latter being the most common. This will typically be either fixed or adjustable; fixed tilt wheelchairs tend to have between 0-10° of tilt, while adjustable tilt wheelchairs tend to allow between 0-30° of tilt. It is worth noting that ‘standard’ wheelchairs usually have a very small amount of fixed posterior tilt, around 3-5°; that is to say, the seat rail is not parallel to the ground.
Tilt in space wheelchair / “TIS” wheelchair	A wheelchair where the seating element can be tilted independently of the wheelchair frame without the need for tools (i.e., the angle of tilt can be changed using a trigger or similar).
Tipping angle	The angle of slope required for a wheelchair / buggy to transition from being stable to unstable.
Up-slope	Positional description of a wheelchair / buggy on stability testing ramp; the user is facing up the incline of the testing ramp.
Wheelchair / buggy system	The combined system formed by the user and their wheelchair / buggy.

Wheelbase	The area between the contact points of the wheelchair and the supporting surface, generally considered as the centres of the front and back wheels. N.B. ’Wheelbase’ can also describe a manual wheelchair base designed to be fitted with a seating system.

Table 1 - Glossary of terms

Common myths/misconceptions

What is stability, stability testing, and stability evaluation

Static and dynamic stability

Factors affecting stability

User factors

Wheelchair factors

Environmental factors

What is stability testing?

When is a stability test required?

Testing and Evaluation

History and prevalence of test methods

Testing equipment and methodologies for static stability

Blocked vs braked stability

Fixed angle ramp

Adjustable angle ramp

Electronic force plates

Manual tip test

Environmental testing using inclines

Suggested decision making tool

Test Method	Advantages	Limitations
Adjustable angle ramp	• Can be used with chairs of all wheel configurations. • Provides a specific angle of tip in all four directions. • Physical demonstration of limitations to the user and / or carers. • Reduced manual handling compared to a fixed angle ramp. • Potentially a portable system. • Low equipment cost. • Users are able to experience the points at which the chair becomes unstable.	• Manual handling risks remai when the slope is inclined. • May be unsettling for occupant.
Fixed angle ramp	• Can be used with chairs of all wheel configurations. • Physical demonstration of limitations to the user and / or carers. • Potentially a portable system. • Low equipment cost. • Users are able to experience the points at which the chair becomes unstable.	• The test output is only pass or fail, which gives no indication of the extent of pass or fail, e.g., a failure on a 12° ramp means the chair is stable anywhere between at 11.9° and 0°. • Manual handling risks. • May be unsettling for occupant.
Electronic Force Plates	• Improved user experience and safety since the wheelchair does not need to tip towards its limit. • Quickly determining tipping angles for various scenarios and iterations of prescription. • Can take up less space for storage.	• Most only work with wheelchairs that have four wheels. • Reliant on hardware and software working correctly. • Requires calibration to discover confidence in the output.

		• Reliant on mathematical assumptions and some understanding of the underlying principles by the operator to ensure that these assumptions are not voided during testing and that the outputs are reasonable. • User does not get an impression of what the maximum tipping angle feels like. • Can be expensive and difficult to obtain and maintain.
Manual Tip Test	• No or very limited equipment required. • Generally quick to perform. • Can give an indication as to whether more formal stability testing is indicated. • Users are able to experience the points at which the chair becomes unstable. • Active user participation in testing and decision making for user-initiated tests.	• Manual handling risks. • Limited or unreliable numerical output. • Variation between assessors. • Risk of user injury. • Cannot safely assess lateral stability. • Typically can only be used for manual wheelchairs.
Environmental testing using inclines	• Can look at certain dynamic elements of stability as well as other important factors (such as pushing efficiency). • Can be used with chairs of all wheel configurations. • Physical demonstration of limitations to the user and / or carers. • Users are able to experience the points at which the chair becomes unstable.	• Risks associated with getting to and using public or well trafficked areas and liability issues if using public land or land owned by a third party. • Privacy and confidentiality issues. • Limited based on availability in the surrounding area and may not be conveniently located. • May not be suitable for use in all weathers or seasons. • A wider range of potential issues with the testing area (e.g., ground conditions).

What to do with data produced

Application to the real world

Reference angles for stability

Stability outside of testing - real life use of equipment

Functional use and ‘how things should be’ vs reality

Fitting accessories, other fitted third-party items, and Electronic Assistive Technology

Electronic Assistive Technology

Stability and the effect on sliding and traction

Method for influencing stability and mobility

Methods for increasing wheelchair stability

Methods for decreasing wheelchair stability

Fluidity of stability, and the problem of optimal stability

Dynamic Stability

Testing equipment and methodology for dynamic stability

Tests for rearward dynamic stability

Tests for forward dynamic stability

Tests for dynamic stability in lateral directions

Scoring system for dynamic stability

Table 2 – A scoring system for quantifying response of wheelchair test manoeuvres for dynamic stability - reproduced from ISO7176-2

Observed dynamic response		**Score**
No tip	At least one lifting wheel remains on the test plane.	3
Transient tip	All lifting wheels lose contact, then drop back onto the test plane, whether or not any anti-tip devices contact the test plane.	2
Stuck on anti-tip device [a]	All lifting wheels lift off, the wheelchair anti-tip device(s) contacts the test plane, and the wheelchair remains stuck on the anti-tip device(s).	1
Full tip	The wheelchair tips completely over (90° or more from its original orientation) unless caught by a restraining device or test personnel for test purposes.	0

[a] When determining whether the wheelchair is “stuck” on the anti-tip device(s), this implies that the wheelchair occupant could not easily restore the wheelchair to the upright position without assistance while remaining seated in the wheelchair. If the wheelchair is not equipped with an anti-tip device a score of 1 cannot be awarded.

Guidance relating to the measurement of dynamic stability in power chairs

Conclusions

Recommendations for future work

Testing ramps

There have been several independent designs of stability testing ramps, of both fixed and angle adjustable types; however, there is not currently a commercially available design available. At the time of writing, the prevailing method of obtaining testing ramps is to commission one with an appropriate local fabrication service with a locally developed design.

Future work would include the development and validation of an open-source testing ramp design.

Electronic force plate systems

Sourcing electronic force plate systems is extremely difficult, despite a number of projects aimed at developing newer versions of these devices. While the various equations used in some devices can still be found in published work and there are a number of mathematical models available to interpret readings, there are no real open-source or commercial systems available for services to purchase.

On-board data recording

As has been stressed throughout this document, static testing is only useful up to a point, and the use of wheelchairs is as varied as the people using them. Therefore, data logging of various information such as forces, angles, pushing / motor power, etc., for real life wheelchair use would provide significant information for tuning the setup of wheelchairs for their users.

Universal standardised testing protocols and decision making guidance

While this document has hopefully collated a range of useful information relating to when testing might be considered, carrying out testing, and clinically interpreting the results obtained, and ISO 7176 does provide some potentially clinically applicable testing methods, there remains a need to standardise this across wheelchair services and ensure best practice.

References

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Appendix 1: Stability Assessment Checklist

Please note that these are suggestions of considerations relating 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.

Appendix 2: WestMARC guidance on the measuring of dynamic stability in power chairs

This guidance was developed by West of Scotland Mobility and Rehabilitation Centre (WestMARC), Glasgow and is reproduced with their permission.

Introduction

Rear wheel braked Static stability is relatively simple to measure using a Force plate stability rig and associated software. This should always be carried out 1st and CoG position optimised before carrying out dynamic testing. Ideally achieving 60-70% weight over rear wheels but ensuring a rearward braked tipping angle of 20° or higher. This ensures good traction and helps prevent rearwards tipping on acceleration up a slope. If using a mid wheel drive, 50% of the weight should be over the centre drive wheel if possible, however not mandatory as the suspension in these chairs will accommodate some leeway.

The end user should be in their final prescribed sitting position before carrying out dynamic testing (seat to ground height; seat depth/width; seat tilt angle; etc)

Dynamic stability is much harder to measure and at present (May 2025), must be measured in an objective assessment of the chairs performance while being driven by the end user. With that in mind, these following assessment techniques are to be used as a guide and only utilised by suitably trained clinicians whom have an understanding of power chair performance and CoG adjustment.

The tests used have been developed using ISO 7176-2 as a guide. The test methods have had to be modified due to the constraints involved in the clinical setting, either within a clinical centre or at the patient’s home/outdoor environment and also the time involved in carrying out the tests.

Before testing the chairs dynamic stability, the patients CoG position should have been optimised following static stability test methods

Unfortunately, if these tests result in poor performance (loss in traction and/or loss in wheel contact with the ground beyond a reasonable level (with MWD chairs)) a change in prescription may be required which can be unfeasible due to time and costs required.

However there are changes that can be made quickly and cheaply to improve dynamic stability. Such as: reducing the accelerations and decelerations in the drive profiles; tweaking the CoG position of the user to try and make dynamic stability more favourable (including height); tweaking suspension (firmer preventing wheel lift and compression resulting in lurching); discussing with the user the limitations of the chair in certain situations (depending on cognition); getting the user to tilt the chair up or down depending on the direction of slope)

Dynamic stability focus for rear wheel drive chairs

From a standing start, accelerate up a slope of max 7°. Start in a slow speed and repeat the test to max speed. If the front castors lift up, there is a potential issue and changes should be made. The patient may realise what they need to do with their body to counteract this; They could tilt the chair forwards; accelerations could be reduced; CoG could be brought forwards without reducing the weight over rear wheels too much.

From a rolling start, go down a slope of max 7°, and ask the patient to remove their hand from the control. The chair should decelerate and stop in a controlled manner. If the rear wheels lose traction or lift, all control is lost. This can be more dangerous than a potential tip. Changes must be made to prevent this such as reducing the deceleration or max speed; Moving CoG rearwards without making tipping backwards a risk; seeing if the user can lean or tip the chair backwards when going down a slope.

Lateral stability – This is more difficult to assess. A drop kerb/camber and pavement can be used, with the user traversing the pavement, down the drop/camber, and then back up the other side, following the dip in the kerb. How does the chair perform? Does the chair lurch to the side? How many wheels leave the ground and does it look manageable for that patient to cope with?

Driving rearwards down a ramp (WAV?). Do the front wheels lift?

Dynamic stability focus for Mid-wheel drive chairs

The same as above applies, however suspension systems are more substantial resulting in the chairs being more forgiving. The suspension will compress down at the back when going uphill preventing the front wheels leaving ground, until it bottoms out. This can happen in aggressive acceleration or poor CoG set up. Or the user being heavy. When going down hill, the rear wheels may leave the ground on deceleration and the front of the seat may tip forwards which will be unnerving for the user. Deceleration parameters can be reduced, or the seat can be tilted when going down hill. Potentially a different mid wheel drive chair could be used which prevents this lurching.

Lateral stability – As above, but again the suspension can absorb undulations a lot better in drop kerbs and cambers, which can make mid-wheel drive chair much safer for outdoor users.

Driving rearwards down a ramp (WAV?). Do the front wheels lift? This is more forgiving in a mid-wheel drive and some front wheel lift can be expected.

Appendix 3 – Images and examples of stability testing ramps

Figure 2 - Portable, folding, angle adjustable ramp - deployed

Figure 3 - Portable, folding, angle adjustable ramp - stored

Figure 4 - Portable, folding, angle adjustable ramp - angle indicator

Figure 5 - Portable, folding, angle adjustable ramp - lifting jack fixation point

Figure 6 - Portable, folding, angle adjustable ramp - folding ramp

Figure 7 - Portable, folding, angle adjustable ramp - lifting jack with stored ramp

Figure 8 - Portable, folding, angle adjustable ramp - lifting jack

Figure 9 - Fixed angle ramp stored against a wall

Figure 10 - Fixed angle ramp deployed

Appendix 4 – PMG 2024 responses to testing

methods used

The Stability working group ran a breakout session at the PMG conference in July 2024 to facilitate discussions around stability in wheelchairs. At the beginning of each session, the team took a quick census of what methods the population of the room used in daily practice. The data from the two sessions is compiled in the table below:

What methods do you use?

Method	Session 1	Session 2	**Total**
Environmental Assessment	11	12	23
Electric Ramp	4	4	8
Variable Ramp	10	2	12
Fixed Ramp	4	6	10
Manual Tip	20	30	50
Total	49	54	103

Table 2 – Census of testing methods used by professionals in PMG breakout rom

Caveat: This census was a rough count of hands raised. The data may not be precise; however, rough trends can be observed. Note: people were able to raise their hand for more that one method.

Appendix 5 – Swansea research into testing methods used

Testing Method		Number of Services/Trusts
Static ramp		5
Load cells		4
Multiple/Additional methods		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

Table 3 - List of services and the testing systems they employ for stability testing