

The question of scooter stability keeps cropping up and until now we have responded to people individually. Finally Doug and I put our heads together for a combined response expressing our opinion on the age old question.....

Scooter Stability- Should people with a disability only consider four wheeled scooters as a mobility solution?

Ian Denison [PT ATP](#) and Doug Gayton [ATP](#)

Typical Question

Hi Ian--thanks for emailing. I'm hoping you're still in the business of assessing power mobility aids as I have a question I'd like to put to you and your team.

Veterans Affairs (Canada) recently instigated a guideline that they'll no longer provide funds for 3 wheeled scooters. Their advisors claim they are too dangerous, i.e. tippy, and they're concerned about liability. I've recently asked a couple of suppliers if they have any comments about the safety of 3 vs. 4 wheels and got ambiguous answers, to say the least. Suppliers on the Coast had assured me that they were equally safe and that drivers were just as apt to tip 4 wheelers as 3, i.e. it was the driver and not the machine.

Typically, I've prescribed 3 wheelers when (a) a power w/c isn't indicated; (b) client needs lots of maneuverability; or (c) client has long legs and can't find sufficient leg room with a 4-wheeler without resting feet on the front wheels' housing. (I'm a Community OT.)

Do you have an opinion on safety of 3 vs. 4 wheelers? Observations / anecdotes? Is there any published research on this subject? (Have been toying with the idea of doing one myself if I can't find documented evidence...)

At the very least, need to educate myself, as would hate to prescribe something to a client that has been found to be hazardous.

Thanks, Ian -- Cheers, Jackie

Response

Oh boy!

Sweeping statements and blanket policies sure make it easy for people who don't understand a subject very thoroughly. In this case it will deprive someone of what is possibly the best solution for their particular and on-going needs. I am going to take time to answer your questions thoroughly because it keeps cropping up and clarification is necessary.

A scooter can tip in several ways the main four being:

1. When the driver steps on the edge of the platform the scooter can tip sideways
2. Traversing a side slope the scooter can tip over sideways
3. Going up a hill the scooter can tip over backwards
4. Turning sharply at speed can cause the scooter to tip sideways

In addition; consider that improper, yet understandable, loading of groceries, shopping, children, or pets may result in poor stability, especially where the centre of gravity may be in motion.

These four situations can be modeled mathematically, unfortunately I don't have the engineering training to create the equations, however I can list factors to consider and make some statements based on my observations.

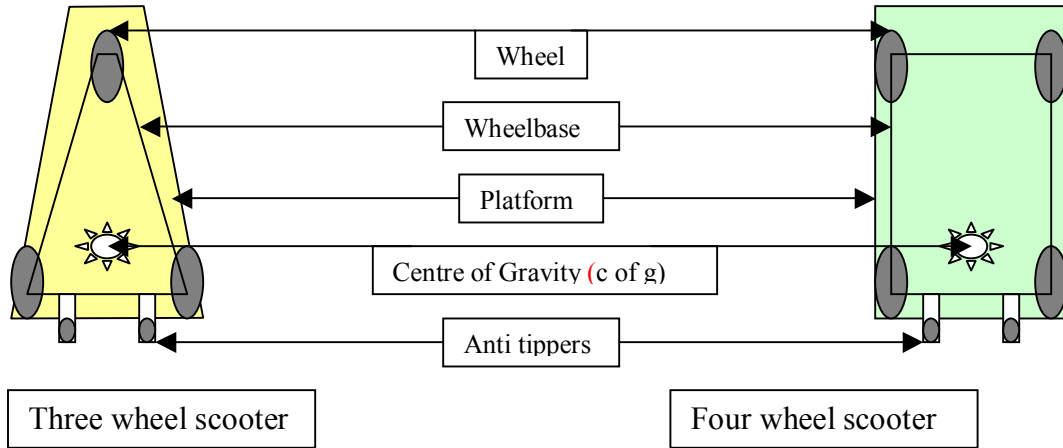
The first three situations are easier to understand than the fourth and can be considered together under the heading Static Stability. Even though examples 2 and 3 occur when the scooter is moving, there are no acceleration forces and Newton's 1st law applies. In the fourth situation deceleration is the key element and Newton's 2nd law applies. This situation will be discussed under the heading Dynamic Stability.

The critical factors that need to be considered are:

- Wheel base
- Location of centre of gravity
- Turning radius
- Platform
- Driver Skill

Diagrammatic Representation of Scooters

Plan View



Elevation



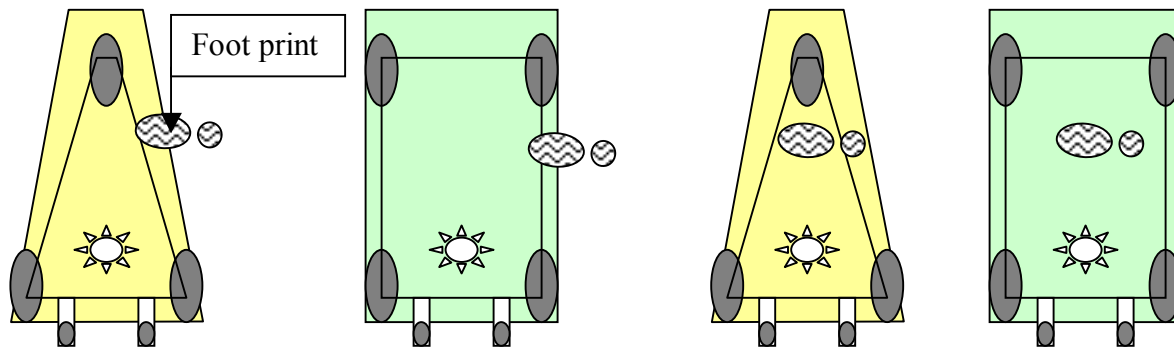
Rear View



Static Stability

Situation 1. Standing on edge of platform, scooter tips sideways.

This is related to the amount the platform overhangs the wheelbase and also the weight of the scooter relative to the driver. If the driver stands on the edge of the platform to get on and off and the platform overhangs the wheelbase by a large amount then the long lever arm will cause the scooter to tip sideways. If the client is heavy and the scooter light the tendency to tip will be increased. If the driver places his or her foot within the wheelbase no tested scooter tipped.



Step here and unit may tip

Transfer Stability

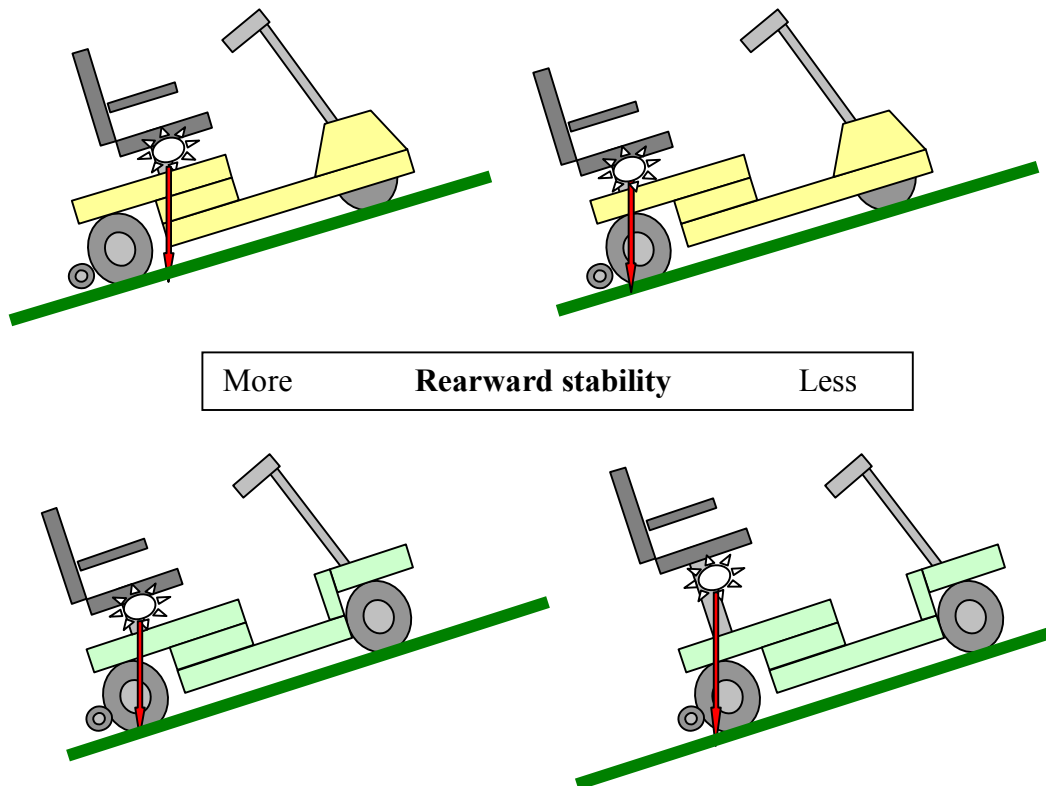
Step here and unit will be stable

My last test of scooters involved 48 models, 28 of which had 3 wheels. 5/28 three wheelers tipped with me standing on the edge of the platform and 1/28 remained on all wheels even when I leaned back. Of the 20 four wheeled models 2/20 tipped and 12/20 were stable despite my leaning back.

N.B. Some three-wheeled scooters have supplementary wheels along the sides of the frame to limit the amount the scooter can tip.

Situation 3. Going up hill, scooter can tip backwards.

This stability issue has very little to do with the scooter having three or four wheels. Tendency to flip backward is only affected by the location of centre of gravity. The further back, and the higher the centre of gravity, the less the angle at which a scooter will tip. Anti tippers are employed on both types of scooter to prevent tipping too far.

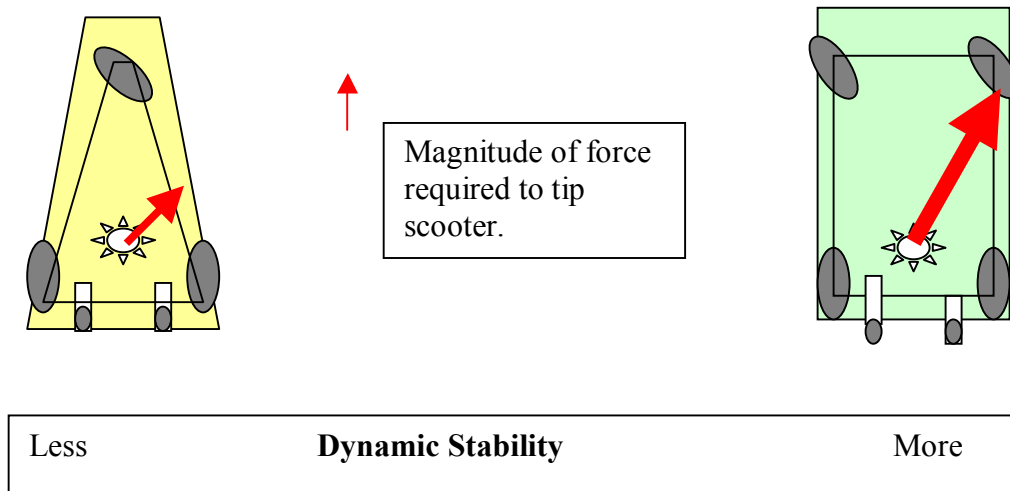


6/28 three wheelers were below average, 4/28 were better than average.
6/20 four wheelers were below average, 3/20 were better than average.

Dynamic Stability

Situation 4. Turning sharply at speed can cause the scooter to tip sideways.

Dynamic stability is affected by turning radius and the width of the wheelbase. During this maneuver the centre of gravity is displaced forwards and laterally i.e., diagonally forwards. If it moves outside the wheelbase the scooter will lift a back wheel and the driver could be pitched out. This is where a four-wheeled scooter has two inherent advantages. Firstly, the wheelbase is wider at the front and secondly due to the steering linkages the front wheels cannot be turned as sharply as a three-wheeler therefore the displacing force is less and in a more forward direction.



1/28 three wheeler had better than average dynamic stability, 9/28 were worse than average.

12/20 four wheelers had better dynamic stability, 1/20 was worse than average.

However, a moderately aware driver with some trunk control will anticipate a lateral tip and either slow down on entry or reduce the sharpness of the turn.

Summary

An unbiased reader will probably determine that while there are no absolutes four wheeled scooters certainly tend to be more stable than their three wheeled brethren. If stability is the only issue considered; then they might also conclude it is reasonable to limit a consumers choice to four wheeled scooters. The same reasoning can be applied to motor vehicles. If stability were the only factor considered when selecting a vehicle we would all be driving a wide sedan with a modest engine. No trucks, no SUV's, no mini vans, no motorcycles, and no buses. Clearly the number and variety of vehicles seen on the road indicates characteristics beyond stability were considered when determining the most appropriate vehicle for an individual; these vehicles were selected to meet needs beyond stability, so it is with scooters.

While testing scooters I looked at performance in 12 critical areas:-

- Speed
- Range
- Stability
- Manoeuverability
- Braking
- Outdoor performance
- Transfers (unassisted)
- Comfort
- Human Factors
- Carrying Basket
- Battery Charger & Ease of Use
- Dimensions
- Transportability

Any part of all of these areas could be the overwhelming reason why an individual selects (or more likely eliminates) a certain scooter or scooter family; even something as seemingly inconsequential as a basket can make the difference. A loaded basket mounted on the tiller makes steering very difficult whereas a frame-mounted basket has no impact on steering.

A scooter which is stable may be lacking in manoeuverability; if that same manoeuverability is what someone needs perhaps a three wheeled scooter is the best choice -- and policy makers should not be making particular choices unavailable through well intentioned, albeit misdirected, concern about client welfare or their institutions liability.

Client awareness, or driver skill has an enormous impact on the successful use of a three-wheeled scooter. In indoor applications a scooter user is hardly likely to come across a steep side slope or be traveling at speeds adequate to pitch him out of the scooter if turned too sharply. Therefore the main concern is how does the driver get on and off the scooter and are they able to understand the limitations of their particular scooter.

It is better, in my view, to perform a thorough assessment of the consumer's abilities and needs, and match those same abilities and needs to the appropriate mobility device -- whether it be a three wheeled scooter, a four-wheeled scooter, a power chair, a manual chair, or a walker.

I hope this long answer to your question helps somewhat.