

## **Scooter Tippiness- Should three wheel scooters be replaced by four wheel scooters?**

### **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 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 needs. I am going to take time to answer your question thoroughly because it keeps cropping up and clarification is necessary.

A scooter can tip in one of four ways:

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.

All of these 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

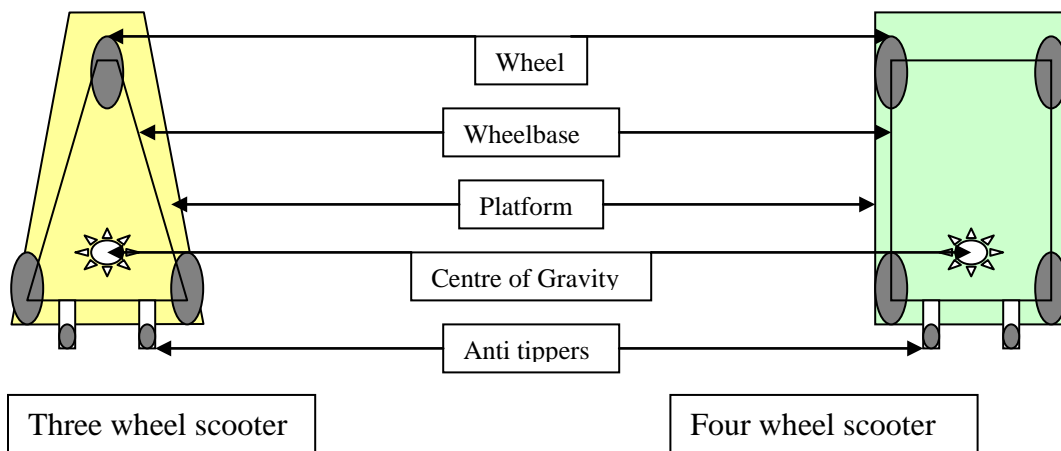
Newtons 1<sup>st</sup> law applies. In the fourth situation deceleration is the key element and Newtons 2<sup>nd</sup> law applies this situation will be discussed under the heading dynamic stability.

The critical factors that need to be considered are:

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

## Diagrammatic Representation of Scooters

Plan View



Elevation



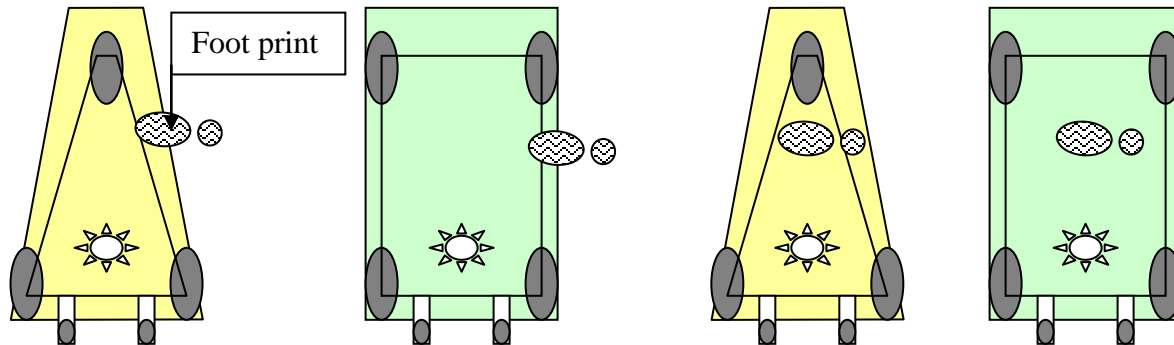
Rear View



## 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 scooter tips.



Step here and unit may tip

**Transfer Stability**

Step here and unit will be stable

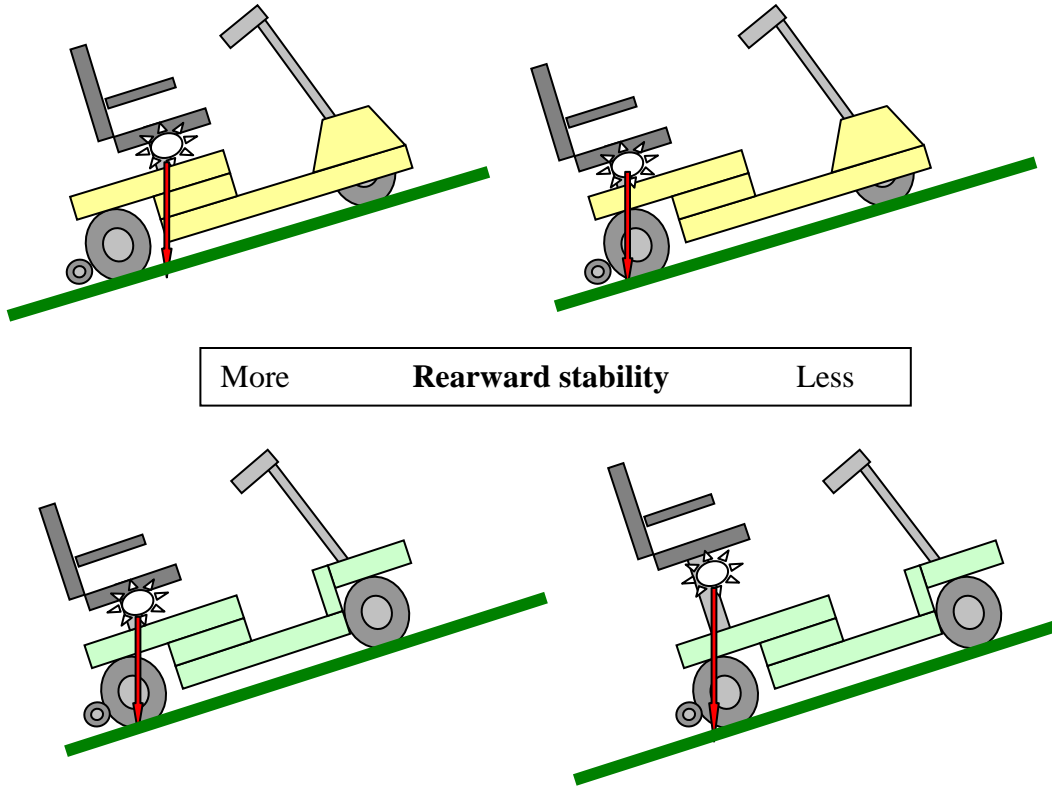
My last test of scooters involved 48 models, 28 of which had 3 wheels. 5/28 three wheelers tipped with me standing on the edge of the platform and 1/28 remained on all wheels even when I leaned back. Of the 20 four wheel models 2/20 tipped and 12/20 were stable despite my leaning back.

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 back is only affected by the location of centre of gravity (c of g). The further back and higher the c of g the less the angle at which a scooter will tip. Anti tippers are employed on both types of scooter to prevent tipping too far.

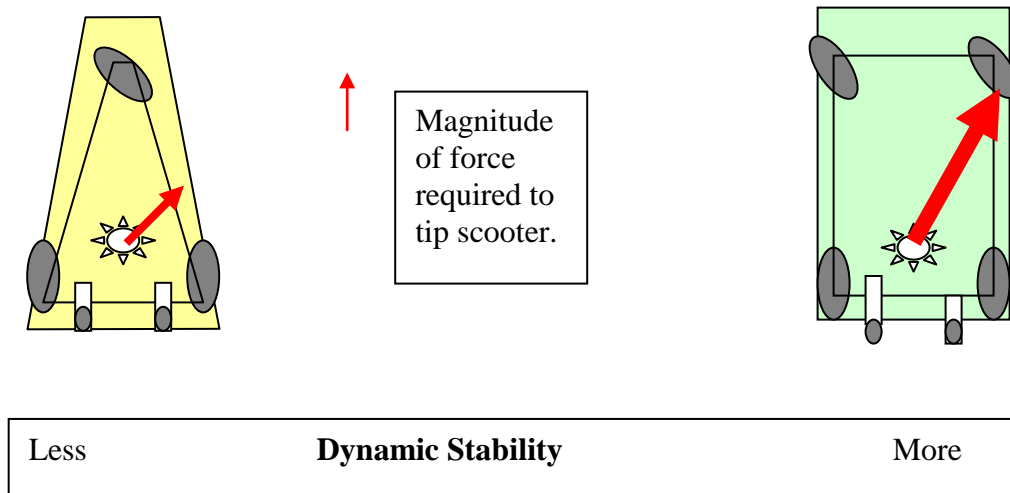


6/28 three wheelers were below average, 4/28 were better than average.  
6/20 four wheelers were below average 3/20 were better than average.

## 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 and the displacing force is less and in a more forward direction.



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

12/20 four wheelers had better dynamic stability, 1/20 were 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 absolute statements four wheel scooters certainly tend to be more stable than their three wheel brethren. If stability is the only issue 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 all these vehicles were selected to meet needs beyond stability, so it is with scooters.

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

Speed

Range

Stability

Maneuverability

Braking

Outdoor performance

Transfers

Comfort

Human Factors

Basket

Battery Charger

Dimensions

Transportability

Any part of all of these areas could be the overwhelming reason why an individual selects a certain scooter; 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 that is stable will not be maneuverable and if that is what someone needs perhaps a three wheeled scooter is the best choice and policy makers should not make that choice unavailable through well intentioned albeit misdirected concern about clients welfare or liability. It is better to perform a thorough assessment of the consumers abilities and needs and match them to the appropriate mobility device whether it be a three wheeled scooter four wheeled scooter, power chair, manual chair or walker.

I hope this long answer to your question helps.