Is a tippy chair easier to push?

(Balancing manual wheelchair stability and 'tippiness' for functional independence)

Lynne Hills, Catherine Holloway, Martin Ferguson-Pell

Rear axle adjustment has an effect on the stability of a user's wheelchair. Usually, wheelchairs are delivered with the axle set in its most rearward position, with guidelines and cautionary advice on its forward adjustment. This is contrary to current clinical recommendations: 'adjust the rear axle as far forwards as possible without compromising the stability of the user' (Paralysed Veterans of America, 2005). Thus, clinicians adjust the rear axle forward incrementally, working with the wheelchair user in order to maintain safety and maximise performance. Theoretically, a more forward axle position has been shown to decrease rolling resistance by reducing the weight transferred through the front castors (Brubaker 1986). Therefore, most clinicians assume that moving the rear axle forward will make the wheelchair significantly easier to propel.

The current study was setup to investigate if this was true. Following rear axle adjustment (from the most stable position to the tippiest position) propulsion moments generated through the push-rim and the castor forces were recorded during a series of straight line, functional mobility tasks performed by a eight experienced wheelchair users. All of whom had a spinal cord injury below the level of T1 and were at least 2 years post injury.

Subjects were set up in a control wheelchair (Quickie GPV) to perform a standardised protocol of functional mobility tasks: propulsion in a straight line over lino & Astro, ascending of a slope and ascending a 3" curb. All 4 conditions were performed in both the tippy and stable configuration.

Castor forces and pushrim forces during each propulsion cycle were gathered using instrumented castors and an instrumented hand-rim (SmartWheel^{TM}).

The synchronisation of the hand-rim and castor data allowed a detailed examination of how the push forces changed during a propulsion stroke, and how this relates to castor weight. By changing the axle position, and hence the tippiness of the chair, it was possible to measure the effect of stability on push stroke dynamics.

It was found that dynamic changes in castor forces were significantly affected by Rear Axle Position (RAP) (Table 1), although this did not translate directly into reduced propulsion forces (Table 2).

Key:
↓ - reduction
↑ - increase
→ - remains the same

RAP	Castor Forces	Peak MZ
Tippy	↓	→
Stable	↑	→

Table 1: Influence of rear axle position on steady state castor forces and push-rim moments

Terrain	Castor Forces	Peak MZ
Lino	→	→
Astro	↑	→
Slope	→	↑

Table 2 : Influence of surface of castor forces and push-rim moments

The kerb analysis showed a greater first propulsion moment was needed with the RAP rearwards (stable) compared to the less stable configuration. For a clinician this makes sense, when teaching users to flip their castors it is much easier for them to achieve this with a less stable configuration. Kerb performance also influences the forces needed to perform flipping the castors to negotiate a kerb.

This study reinforces the importance of configuring a wheelchair for a full range of tasks anticipated for the user rather than simply those used for forward movement whilst also considering the frequency of such tasks as part of their daily routine.

The message to clinicians is that they should not be concerned about the effect of RAP on propulsion forces in a straight line for these types of conditions aside from negotiating a kerb. This study does not however provide information about the effect RAP may have on propulsion forces when manoeuvring, an important consideration for future studies.

References

1. Paralysed Veterans of America (2005) – Preservation of Upper Limb Function Following Spinal Cord Injury: A Clinical Practice Guideline for Health-Care Professionals. Consortium for Spinal Cord Medicine[i]
2. C. E. Brubaker, "Wheelchair prescription: an analysis of factors that affect mobility and performance," J Rehabil Res Dev 23, no. 4 (1986): 19-26