MEDICAL EQUIPMENT SPECIALISTS

Want to Learn More -->
Call us at (772) 777-8109

The Significance of Tilt-In-Space Manual Wheelchairs for Individuals Following CVA

by Curt Prewitt, MS, PT, ATP and Deborah L. Pucci, PT, MPT

Ki Mobility

According to AHA statistics, more than 795,000 people in the United States suffer a CVA annually (Benjamin et al., 2017). Despite this significant number, CVA does not figure as prominently in discussions about the impact and importance of complex rehabilitation technology as neurologic disabilities such as CP, ALS, MS, and SCI. Persons who have suffered from a stroke present with a wide array of functional impairments. For many of these individuals the capacity for independent mobility has been problematic, sometimes due to their impairment(s), but in many cases the equipment available to them has contributed to their disability becoming a handicap.

Stroke reduces mobility in more than half of those over age 65 (Benjamin et al., 2017). Most of these individuals are diagnosed with hemiplegia or hemiparesis, reducing motor control of one side of their body; upper extremity, lower extremity, or both. Because of these impairments, stroke survivors commonly present with a high need for positioning, limited independent mobility and a limited ability to independently reposition themselves. They would benefit from a seating and mobility system with the ability to adjust seat angles in order to provide postural support to counter the effects of hemiparesis, help maintain skin integrity, and optimize positioning for specific activities, such as independent propulsion, transfers, eating and ADLs. Additionally, they or their caregivers, may benefit from a mobility system which is easy to maneuver and transport.

Most stroke survivors with the potential for independent manual wheelchair mobility receive a lightweight manual wheelchair (K0003) or a high strength, lightweight manual wheelchair (K0004). Medicare's limited definition of adult manual wheelchairs in these categories includes seat widths and depths between 15"-19", a weight capacity of 250 pounds, weight between 32 lbs to 36 lbs, and fixed, swing away, or detachable armrests and footrests. As Medicare reimbursement for chairs has declined, however, these chairs have become less capable. It is common that they are not well fit to the individual user, have fixed or minimally adjustable seat angles, rear axles, and casters; all of which can contribute to inefficient mechanics and difficulty with maneuverability. This leads to greater energy expenditure, poor body mechanics, difficulty maneuvering and transferring in and out of the chair, poor sitting postures that can also lead to shear and an increased risk of developing a pressure injury, and limited independence with ADLs.

While adult manual tilt-in-space wheelchairs can address many of the seating and mobility needs of stroke survivors, they are often not prescribed due to limitations related to independent propulsion, weight, and transport. Most tilt-in-space wheelchairs do not fold for ease of transport and have seat height and rear wheel adjustability that do not promote independent foot or hemi-propulsion. Additionally, their weight is often an additional barrier for independent propulsion or transport in a non-accessible vehicle. Despite the limitations of tilt-in-space wheelchair design, the benefits of an adjustable seat angle for independence with mobility and activity specific ADLs has been well documented.

In a qualitative study on the use of power and manual tilt-in-space chairs in residential facilities, Shankar et al. (2015) identified taking control, promoting comfort, and mobilizing for participation as themes for use of such chairs. Their findings demonstrated that users' independence with propulsion and ability to request and direct staff assistance affected the control that they had in their wheelchair, as well as occupational engagement. Residents who were independent with mobility had more control over the identified themes: comfort, mobility, and participation.

In a clinical trial on preventing pressure ulcers with wheelchair seat cushions, Brienza et al. (2010) concluded that skin protection cushions used with fitted wheelchairs lower pressure ulcer incidence for elderly nursing home residents and should be used to help prevent pressure ulcers. Moreover, in the context of their investigations they made the two following statements: "cushions cannot compensate for violation of basic principles of body mechanics in wheelchair fitting" [p. 2], and "poorly fitting wheelchairs are likely to result in poor posture that will result in higher pressure and increased pressure ulcer risk" [p. 7].

Brienza et al. (2010) also noted the significance of being active and having independent mobility. Investigators found that pressure ulcers occurred in only 5.8% of the 69 participants who were independent in their ability to propel their wheelchair, as compared to 19.0% of the 153 participants who were dependent for their wheelchair propulsion. In short, those with independent wheelchair propulsion experienced less than 1/3 the incidence of pressure ulcers than did their dependent counterparts.

For many, difficulties with independent mobility may serve to discourage them from being as active or as mobile as they can or might desire to be. This diminished activity might prolong the duration or stifle the progress of a rehabilitation program. Conversely, a person who can be more active and more mobile, may be more motivated, more engaged, and potentially progress physically at an improved pace or to a greater degree. A UK study on predictors of walking following CVA, found that participants who were able to self-propel a wheelchair within a week of admission to a stroke rehabilitation program were over 20 times more likely to ambulate at discharge (Singh, Hunter, Philip & Todd, 2006).

Another important consideration for individuals using a wheelchair, is the ability to change position to help maintain skin integrity. Much debate exists regarding the most effective position to achieve an adequate pressure relief, how often an individual must perform a weight shift, and how long the position should be maintained. The Consortium for Spinal Cord Medicine (2014) guidelines for individuals with spinal cord injury recommend weight shifts at 15-30 minute intervals for approximately 2 minutes.

Despite the widely held standard that a tilt degree of at least 45° is required for an effective weight shift, work by Sonenblum and Sprigle (2011a), has identified that small and medium tilts of 0° to 29° are performed by wheelchair users more often than larger tilts of 30° to 45°. Additionally, they concluded that tilts are performed with much less frequency than prescribed. It should be noted, however, that all changes of position affect tissue loading and can impact position for comfort and function

Concern for the impact of shear as a contributing factor in the formation of pressure injuries has been a topic of investigation for many years (Bennett, Kavner, Lee, & Trainor 1979; Guttmann, 1976; Reichel, 1958) and a growing body of research supports the damaging effects of impaired blood flow and tissue deformation due to shear forces (Gawlitta et al, 2007; Gefen, van Nierop, Bader, & Oomens, 2008; Stekelenburg et al, 2007). In their definition of a pressure injury, the National Pressure Ulcer Advisory Panel (NPUAP) states that "the injury occurs as a result of intense and/or prolonged pressure or pressure in combination with shear " [p. 12] (Haesler, Ed., 2014). Further research is needed both to differentiate the risks associated with pressure injury due to impaired blood flow and tissue deformation, as well as develop practice guidelines for prevention. Studies, however, have pointed to potential means to decrease both risks through the use of tilt at smaller degrees than previously identified for an effective pressure relief. In a study on the impact of tilt on blood flow and localized tissue loading, Sonenblum and Sprigle (2011b), did not measure tissue deformation or shear, but did identify that 15° of tilt in a sample of individuals post spinal cord injury demonstrated "a small (8%) but significant increase in superficial blood flow" [p. 9] at the ischial tuberosity. Hobson (1992), in a study comparing the effects of posture on pressure and shear, demonstrated that among both nondisabled subjects and individuals post spinal cord injury, a full-body tilt to 20° reduced tangential shear forces on the sitting surface 85%.

Transfers are an area that must be addressed when considering position changes for function. Numerous users post CVA could benefit from a wheelchair transfer position different than that for propulsion. A rear seat height lower than the front can assist to help stabilize a user's pelvis to prevent a tendency toward sacral sit and reduce shear strain common with foot propulsion. A low seat height, however, can negatively impact transfers. Over 40% of elderly individuals experience difficulty rising from a seated position (Chamberlain & Munton, 1984). Elderly individuals have also been shown to use a strategy of increased trunk flexion for sit to stand transitions (Lee & Lee, 2016; Papa & Cappozzo, 2000; Son, Park, Kang, & Seo, 2005). At lowered seat heights, this strategy is used by both healthy individuals and those with hemiplegia (Papa & Capozzo, 2000; Son et al., 2005). It can increase the time for the transition (Lee & Lee, 2013; Ng et al., 2013, Papa & Cappozzo, 2000) and increase incidence of falls. Conversely, a seat height of 120% lower leg length has been shown to improve the ability to transition from sit to stand, demonstrating the benefit of seat adjustability for propulsion versus transfers (Weiner, Long, Hughes, Chandler, & Studenski, 1993) .

Reaching from a seated position is another task necessary for various ADLs. A stable base of support, and use of a single upper extremity, are necessary for tasks such as grooming, oral facial hygiene, meal preparation, and eating. Chari and Kirby (1986), demonstrated that forward reach distance at a tabletop level is improved in all planes with both bilateral thigh and foot support on the ground, reinforcing seat height adjustment that allows foot support on the ground.

Head position is also critical for function and performance of ADLs. Post CVA, muscular weakness, decreased endurance, dysphagia, and postural asymmetries can impact eating, breathing, visual access to the environment, and occupational engagement. Although no optimal body position has been found to decrease aspiration for individuals with dysphagia, the ability to achieve a chin tuck and head rotation to the non-affected side has been shown to minimize aspiration and increase bolus tolerance (Ertikin et al., 2001; Hitoshi, Yoko, Sumiko, & Eiichi, 2011). Additionally, sitting at greater than 60° from supine is necessary for independence with eating, sitting can increase alertness (Ertikin et al., 2001; Hitoshi et al., 2011), and sitting for 2 hours post meal can help prevent reflux (Matsui, Yamaya, Ohrui, Arai, & Sasaki, 2002). In addition to impacting swallow, forward head posture in healthy males has been shown to have an immediate negative impact on respiratory function (Zafar, Albarrati, Alghadir, & Iqbal, 2018). It has been correlated with decreased forced vital capacity and increased activity of accessory respiratory muscles (Kang, Jeong, & Choi, 2018). The average weight of the human head is 10-11 lbs in an upright neutral position, placing 10-12 lbs of force on the neck. Hansraj (2014) has shown that forward flexion significantly increases muscular force required to maintain head position. At just 15° degrees 27 lbs of force is placed on the neck and at 60° degrees that increases to 60 lbs., making it a significantly more difficult task to maintain an upright head position over time. Given the above factors, it stands to reason that post CVA, many individuals could benefit from changes in seat angle to help overcome strength and postural challenges to achieve and maintain optimal head positioning.

With all the potential benefits of an adjustable seat angle for individuals post CVA, a tilt-in-space chair innovatively designed to address concerns regarding transport, weight, and propulsion is highly desirable. A chair that folds and has a transport weight ≤ 36 lbs would challenge the commonly prescribed upright manual options. A customized fit for the user would increase the potential for independent mobility, allow for better balance of the system specific to the user, improve postural support and body mechanics, and reduce energy expenditure. This would require a seat angle that can be actively adjusted to achieve optimal positions for pressure management and a variety of MRADLs. The ability to set the seat angle without raising the front seat height would allow a foot propeller to achieve functional independent mobility without pulling their pelvis forward in the seat. Adjustability of angles also means the user could achieve the optimum angle to safely eat and swallow without an increased risk of aspiration and maintain head alignment for breathing and engagement. The ability to bring the chair back up to level to improve reach for tabletop activities and ease of transfers could markedly improve participation in ADLs. By being more capable of individualized fit, a tilt-in-space manual wheelchair has the potential to positively impact the gains made in the function for individuals post CVA.

Ki Mobility has introduced a chair that does this very thing: Liberty FT, an adult tilt-in-space (E1161) that folds and has a transport weight less than 26 lbs. It can be configured with a more customized fit for the user in need of a manual wheelchair with the option of independent mobility. This configuration/fit capability allows for better balance of the system specific to the user and allows for better body mechanics for the independent propeller, reducing energy expenditure.

Instead of fixed or minimally adjustable seat angles, Liberty FT is a manual tilt-in-space chair that adjusts in a 20° active range, from -7° to 27°. For example; the seat angle can be actively adjusted from 0° to 20° or -5° to 15°. The ability to achieve such angles in a lightweight tilt-in-space now allows the chair to be set at various angles that are optimal for a variety of mobility related ADLs (MRADLs). Very notably, the ability to set the seat angle appropriately for a foot propeller, without raising the front seat height, and thus the foot, means the foot propeller can now achieve functional independent mobility, without pulling their pelvis forward in the seat. The infinite adjustability of angles within the range also means the user can achieve the optimum angle to safely eat and swallow without an increased risk of aspiration. They can also bring the chair back up to level (it can even be set up for some anterior tilt) to facilitate easier transfers, either laterally, or in/out of the front of the chair.

Adjustability in axle position, both horizontally and vertically, allows for a more balanced chair with improved rolling efficiency and easier maneuverability. The difference in energy expenditure for someone in a better configured, better balanced chair is well established. By being more capable of individualized fit, Liberty FT can reduce risk to joints, maintain a safer posture, and result in a user who is more active in general. For those in an active rehab program, this level of activity can have a positive impact on the duration of and the gains made in their rehab plan.

The most notable and unique feature of Liberty FT is its ability to fold into a compact package ideal for transportation. With a transport weight less than 26 lbs., it can be placed into the trunk space of the most compact car, in sections that are easy to handle, even by frail caregivers. Liberty FT, from Ki Mobility, is finally the one wheelchair that offers true portability, enables independent propulsion and provides the benefits of various seat angles in a tilt-in-space chair.

References

Benjamin, E. J., Blaha, M. J., Chiuve, S. E., Cushman, M., Das, S. R., Deo, R., … Muntner, P. (2017). Heart disease and stroke statistics—2017 update: a report from the american heart association. *Circulation*, *135*(10).

Brienza, D., Kelsey, S., Karg, P., Allegretti, A., Olson, M., Schmeler, M., … Holm, M. (2010). A randomized clinical trial on preventing pressure ulcers with wheelchair seat cushions: preventing pressure ulcers with wheelchair seat cushions. *Journal of the American Geriatrics Society*, *58*(12), 2308–2314.

Chamberlain, M. A., & Munton, J. (1984). Designing chairs for the disabled arthritic. *Rheumatology*, *23*(4), 304–308.

Chari, V. R. & Kirby, R. L., (1986). Lower-limb influence on sitting balance while reaching forward. *Archives of Physical Medicine and Rehabilitation*, *67*(10), 730–733.

Ertekin, C., Keskin, A., Kiylioglu, N., Kirazli, Y., On, A. Y., Tarlaci, S., & Aydoğdu, I. (2001). The effect of head and neck positions on oropharyngeal swallowing: A clinical and electrophysiologic study. *Archives of Physical Medicine and Rehabilitation*, *82*(9), 1255–1260.

Gawlitta, D., Li, W., Oomens, C. W. J., Baaijens, F. P. T., Bader, D. L., & Bouten, C. V. C. (2007). The relative contributions of compression and hypoxia to development of muscle tissue damage: an in vitro study. *Annals of Biomedical Engineering*, *35*(2), 273‑284. https://doi.org/10.1007/s10439-006-9222-5

Gefen, A., van Nierop, B., Bader, D. L., & Oomens, C. W. (2008). Strain-time cell-death threshold for skeletal muscle in a tissue-engineered model system for deep tissue injury. *Journal of Biomechanics*, *41*(9), 2003‑2012. https://doi.org/10.1016/j.jbiomech.2008.03.039

Hansraj, K., (2014). Assessment of stresses in the cervical spine caused by posture and position of the head. *Surgical technology international*, 25. 277-9.

Haesler, E. (Ed.), (2014). National Pressure Ulcer Advisory Panel, European Pressure Ulcer Advisory Panel and Pan Pacific Pressure Injury Alliance. Prevention and Treatment of Pressure Ulcers: Quick Reference Guide. Osborne Park, Australia: Cambridge Media.

Hitoshi K., Yoko I., Sumiko O., Eiichi S., (2011). Body Positions and Functional Training to Reduce Aspiration in Patients with Dysphagia. *Japan Med Association Journal*, 54(1): 35–38.

Hobson, D. A. (1992). Comparative effects of posture on pressure and shear at the body-seat interface. *The Journal of Rehabilitation Research and Development*, *29*(4), 21. https://doi.org/10.1682/JRRD.1992.10.0021

Kang, J.-I., Jeong, D.-K., & Choi, H. (2018). Correlation between pulmonary functions and respiratory muscle activity in patients with forward head posture. *Journal of Physical Therapy Science*, *30*(1), 132–135.

Lee, M. Y., & Lee, H. Y. (2013). Analysis for sit-to-stand performance according to the angle of knee flexion in individuals with hemiparesis. *Journal of Physical Therapy Science*, *25*(12), 1583–1585.

Lee, S.-K., & Lee, S.-Y. (2016). The effects of changing angle and height of toilet seat on movements and ground reaction forces in the feet during sit-to-stand. *Journal of Exercise Rehabilitation*, *12*(5), 438–441.

Matsui, T., Yamaya, M., Ohrui, T., Arai, H., & Sasaki, H. (2002). Sitting position to prevent aspiration in bed-bound patients. *Gerontology*, *48*(3), 194–195.

Ng, S. S. M., Cheung, S. Y., Lai, L. S. W., Liu, A. S. L., Ieong, S. H. I., & Fong, S. S. M. (2013). Association of seat height and arm position on the five times sit-to-stand test times of stroke survivors. *BioMed Research International*, *2013*, 1–6.

Papa, E., & Cappozzo, A. (2000). Sit-to-stand motor strategies investigated in able-bodied young and elderly subjects. *Journal of Biomechanics*, *33*(9), 1113–1122.

Consortium for Spinal Cord Medicine, & Paralyzed Veterans of America. (2014). *Pressure ulcer prevention and treatment following spinal cord injury: a clinical practice guideline for health-care providers.* Washington DC: Consortium for Spinal Cord Medicine.

Shankar, S., Ben Mortenson, W., & Wallace, J. (2015). Taking control: an exploratory study of the use of tilt-in-space wheelchairs in residential care. *American Journal of Occupational Therapy*, *69*(2).

Singh, R., Hunter, J., Philip, A., & Todd, I. (2006). Predicting those who will walk after rehabilitation in a specialist stroke unit. *Clinical Rehabilitation*, *20*(2), 149‑152. https://doi.org/10.1191/0269215506cr887oa

Son S., Park T.J., Kang Y.T., Seo K.E. (2012). Kinetic Analysis of sit to stand movement with change of chair heights in able bodied 60s and 20s women. *Korean Journal of Sports Science*, 2012, 1249-1258.

Sonenblum, S. E., & Sprigle, S. (2011). Distinct tilting behaviours with power tilt-in-space systems. *Disability and Rehabilitation: Assistive Technology*, *6*(6), 526–535.

Sonenblum, S. E., & Sprigle, S. H. (2011). The impact of tilting on blood flow and localized tissue loading. *Journal of Tissue Viability*, *20*(1), 3‑13. https://doi.org/10.1016/j.jtv.2010.10.001

Stekelenburg, A., Strijkers, G. J., Parusel, H., Bader, D. L., Nicolay, K., & Oomens, C. W. (2007). Role of ischemia and deformation in the onset of compression-induced deep tissue injury: MRI-based studies in a rat model. *Journal of Applied Physiology*, *102*(5), 2002‑2011. https://doi.org/10.1152/japplphysiol.01115.2006

Weiner, D. K., Long, R., Hughes, M. A., Chandler, J., & Studenski, S. (1993). When older adults face the chair-rise challenge: a study of chair height availability and height-modified chair-rise performance in the elderly. *Journal of the American Geriatrics Society*, *41*(1), 6–10.

Zafar, H., Albarrati, A., Alghadir, A. H., & Iqbal, Z. A. (2018). Effect of different head-neck postures on the respiratory function in healthy males. *BioMed Research International*, *2018*, 1–4.