Draft of Clinical Recommendations for Use of Power Tilt systems

Power wheelchairs with compatible power tilt options are commonly found in the seating and mobility industry today. Tilt-in-space is defined as the ability of the wheelchair seat and back to rotate around an axis while maintaining a constant seat-to-back angle. The medically necessary criterion frequently used for recommending power tilt systems is user's inability to perform independent weight shifts to decrease potential for skin breakdown. Another common use is to utilize gravity assisted positioning for stability for users with significant physical deformities who also have a need to dynamically come out of tilt for functional activities.

Some research has been published regarding the effects of tilt systems in a variety of areas including physiological, postural and functional as well as investigation into the use of tilt systems and reported benefits by users. A systematic review of the tilted seat position for non-ambulant individuals with neurologic and neuromuscular impairment (2007)[1] concluded that quality evidence to guide the use of the tilted position in seating is lacking. The purpose of this document is to review the literature that does exist concerning tilt systems as well as synthesize the information into recommendations that can assist the health professional both in prescribing tilt systems as well as educating the user in its use. The resulting guide can be considered informed by the data that is known as well as from current clinical practice and expertise.

Physiological effects

Pressure/Load

Numerous studies have investigated the effect of rearward tilt on pressure or load redistribution.[2, 3] These studies used a variety of subject populations, though primarily focused on people with spinal cord injuries. Although different methods were used in these studies, the principal finding throughout all of the results is that *the greater the angle of rearward tilt, the more redistribution of pressure and load off of the buttocks*. None of these studies identified a minimum threshold of tilt required to insure skin integrity. Current systems tilt back to 45-60° from upright and these results suggest that the full range of tilt should be used to maximize reduction of pressure/load off of the buttocks.

Shear

Hobson [4] investigated the tangential shear forces at the body-seat interface in 9 different seat configurations, some involving the combination of tilt and recline. In an upright seat, the body tends to slide forward in the seat, and the shear forces oppose this sliding tendency. Significant shear reductions occurred at 20° of seat tilt, the maximum tilt investigated in this study. Further extrapolation of the results suggests that shear would be eliminated at 25° of tilt, and further tilting would then reverse the shear direction. At this point, the body tends to slide against the backrest. In contrast, recline increased shear forces at the seat-up to 25% with 120° of backrest recline. These results along with the results from a study done by Cooper et. al [5] using a hybrid test dummy suggest that reclining the backrest increases the tendency of the body to slide out of the seat. Aissaoui [2] found similar results, except Aissaoui's data suggests a vertical sliding (the position of the acromion is lowered) during backrest recline, but not necessarily a forward sliding on the seat, potentially due to movement of the pelvis into a posterior pelvic tilt.

Blood flow

Blood flow during tilt has been studied with respect to blood flow in the lower extremities and to blood flow in the ischial region. Shunkewitz et al. [6] found typical tilt postures lead to a slight improvement in lower limb blood flow in subjects with spinal cord injury. Recent work has begun to determine the impact of tilting on blood flow and localized tissue loading. [7] Eleven subjects participated in the study; Laser Doppler Flowmetry (LDF) was used to measure superficial blood flow at the ischial tuberosity and an interface pressure sensor attached directly to the buttocks was used to monitor localized loading surrounding the LDF probe. Data was collected in an upright position, in tilted positions of 15°, 30°, 45° and maximum tilt immediately following upright sitting, and at 30° following 15° of tilt. Blood flow increased significantly from an upright position to all tested positions, including a small, but significant increase at 15° of tilt. However, blood flow did not increase when tilting to 30° from 15° of tilt. Pressure did not significantly decrease at 15° of tilt, but was reduced by all tilts greater than 15°. The results suggest that the mechanism of increased blood flow at 15° of tilt is not solely due to a decrease in interface pressure at the ischial region. This study corroborates the previous studies of pressure during tilt in that pressure under the buttocks is decreased with increasing tilt. In addition, despite limited pressure benefits, there may be a direct benefit from performing small tilts as seen with the significant increase of blood flow at 15° of tilt.

Respiration

Chan and Heck [8] investigated the effects of tilting on subjects with multiple sclerosis. They found a significant improvement in respiratory measures (forced vital capacity and chest expansion) in 25° and 45° of tilt in subjects with multiple sclerosis. In addition, they found a clinically significant increase in voice volume with tilt along with subjective reports in decreased exertion (as a proxy measure of fatigue), although not statistically significant.

Other

Power tilt has been recommended to assist in controlling hypotension initially upon sitting up or in some cases, throughout the day. Some users express the ability to control lower extremity edema with full tilt, with or without elevating legrests. To date, tilt-in-space influence on hypotension or lower leg edema has not been published. A note of caution for use of tilt-in-space: many authors have mentioned that a tilted posture can elicit abnormal tone and righting reactions as the head tries to achieve a vertical orientation.[9-12]

Postural effects

Gravity assisted positioning

In the study referenced earlier by Chan and Heck [8], a statistically significant increase in thoraco-lumbar distance and a decrease in cervico-thoracic distance in subjects when tilted suggests a decrease in kyphosis and forward head posture in tilt. The aforementioned study by Hobson [4] estimated that 25° of tilt would reverse the shear forces on the seat. This finding suggests that positioning would be enhanced in this situation. A study done by Lalonde, et. al [13] demonstrated a 5° and 6° increase in posterior pelvic tilt and hip angle respectively with tilt angles of 25° and 35°. No significant changes were noted at the trunk. In comparison, an increase of 20° of the seat to back angle increased the trunk angle 22° and the pelvis and hip 16°. These results demonstrate a more stable seated posture with tilting vs. recline. In a single-subject design methodology, Angelo [14] found an increase in head control in a child with cerebral palsy using 15° and 30° of tilt versus upright.

These findings suggest that the use of tilt can improve posture for those who do not have the strength to maintain an upright position against gravity. Increased stability may also lead to functional benefits as a result of improved postural stability.

Many clinicians recommend that caregivers tilt the seating system to utilize gravity to ease the effort of properly positioning a person in the wheelchair.

Functional effects

Janssen-Potten et al found that while no increase in functional reach was found when tilting or reclining a wheelchair in persons with low spinal cord injury (SCI) or in able-bodied persons, the ability to control displacement of arms and trunk during reaching improved. [15] This was measured by an increase in the center of pressure displacement during reach in a 7° tilt, 12° tilt or 22 ° of backrest recline compared to a standard configuration (0° of tilt, 10° of backrest recline). The increased center of pressure displacement in the able-bodied subjects was suggested to show more trunk movement during reach. The authors proposed that the same is true with the SCI population, but due to their impaired sitting balance, people with SCI choose to not challenge their reach due to fear of falling.

The ability of a tilt-in –space system to transition from tilt to an upright posture may ease transfers out of the chair and ADL activities such as eating, which has been shown to facilitate swallowing and gastric emptying. [16] This infers that while users may stay tilted throughout the day, an upright posture is sometimes required.

Reported benefits of tilt-in space systems

A few studies [17-19] have gathered subjective feedback from power tilt users on the benefits of tilt. A small survey of 7 tilt-in-space users with multiple sclerosis in the UK [17] revealed that spending more time out of bed was important to this group and the use of a tilt-in-space system allowed users to manage their fatigue during the day without having to return to bed. In addition, the majority of tilt-in–space users were satisfied with the comfort of their chair. In a survey by Lacoste, [18] 97.5% of tilt-in-space users reported daily use of their tilt and/or recline systems and over 70% identified increasing comfort, rest, relaxation, and decreasing pain as reasons they used the systems. In the same study, between 37.5% and 65% of those surveyed stated they used their systems to improve postural control and functional independence such as increasing their stability/balance, repositioning themselves, improving obstacle negotiation, easing transfers, reaching objects at different heights, and easing feeding/ hygiene and table access. Only ≤35% reported use of tilt/recline systems to assist in physiologic functions such as improving breathing, preventing skin redness and pressure sores and avoiding sliding out of the system. The subjective responses received in Sonenblum et. al[19] were similar to Lacoste's results in that a similar percentage reported the use of tilt systems to increase comfort/decrease discomfort, rest/relaxation, posture, and function. However, a high percentage (69%) reported using tilt systems for pressure relief.

The subjects in Lacoste's study reported the magnitude of tilts they used to achieve their reported benefits (increased comfort, rest/relaxation, posture, functional independence and physiologic functions). The authors determined from the subjective reports that large amplitude tilts (31-45°) were used to decrease pain and rest; middle amplitude tilts (16-30°) were used to increase stability; and small amplitude tilts (0-15°) assisted in increasing comfort.

<u>Measured use of tilt-in-space systems</u>

After gathering subjective reports on the use of tilt, Sonenblum [7] instrumented 45 power tilt-in-space chairs and measured wheelchair occupancy time, typical seat position, time spent at small (0-14°), medium (15-29°), large (30-44°) and extreme (≥45°) tilts, and tilt frequency (defined as position changes of 5° or more in either direction that were maintained for 20 seconds). Based on a median day for each subject, the subjects sat in 8° (0°-47°) of tilt for ~12 hours (4.1-24) a day and performed 2.2 tilts (.1-16.6) per hour, but only performed a pressure relieving tilt every 10 hours. Participants in a study by Ding, et al.[20] sat for an average of 11.8 hours per day and tilted an average of 19±14 times per day, or in other words their tilt frequency was approximately 1.6±1.2 tilts per hour. Due to differences in methodology and reporting, it is difficult to determine the similarity between the two sets of results, but they are on the same order of magnitude.

Sonenblum [7] found 81% of the power tilt-in-space user's time was spent in the small range of tilts, 15% in the medium range and1% in the large range of tilt. Note that tilt times do not sum to 100% because independent medians were taken for each range of tilt. The data identified two groups of tilt-in-space users. Users with a single typical tilt position, spent the majority of the day in one position (typically ~6° of tilt) with a small amount of time in other tilted positions whereas those who were continuously moving (defined at > 20% of time in more than one tilt range) throughout the day did not have a typical position. The continuously moving group performed 4 tilts an hour compared to 1.3 tilts in the group who sat with a typical tilt position. The continuously moving group also performed more pressure relieving tilts (defined at >30° lasting > 1 minute) than the typical position group (1 every 4 hours vs. 1 every 14 hours). More subjects in the continuously moving group had sensation vs. the single position group. In regards to pressure relieving tilts, 7of 9 subjects with current pressure ulcers performed more frequent pressure relieving tilts than the median subject (> 0.1/hour). One third of the subjects did not do a pressure relieving tilt at all during their median days. Subjects who reported they were using their tilt systems for pressure reliefs actually did more tilts (2.4 vs. 1 per hour) and more pressure relieving tilts (0.18 vs. 0.0 per hour) than those who did not report use of tilt systems for pressure relief. It's important to note that about half of all subjects reported they performed pressure reliefs in some way besides tilting (leaning forward or sideways).

The finding from Sonenblum [7] that small and medium tilts are more common and that pressure relieving tilts are not done frequently are also consistent with previous research. [19, 20] The finding that the median participant spent 19% of their seated time in a medium, large or extreme tilt is consistent with Ding, et al.'s[20] finding that participants spent most of their time "not upright". Overall, the majority of participants in the studies by Sonenblum et al (77%), Ding, et al. (100%) and Lacoste, et al. (70%) reported using their tilt feature for comfort, discomfort and/or pain. [18-20] Seated comfort and discomfort are complex constructs involving many objective and subjective factors, including those related to the person, seat, and environment. [21] However, despite the complexity, extensive research has been performed and much is known about seated comfort in ergonomic applications. Long term, static sitting is generally associated with discomfort and pain, [22] and therefore ergonomic design has long included dynamic components in most task seating, such as office chairs and truck seats. Adjustable and dynamic seats affect both comfort and discomfort by allowing a variety of comfortable seated postures and by providing users with a means to address discomfort. Decades of literature have shown that increased body movements while sitting occur as a response to discomfort. [23] Among the participants who used multi-modal tilt behavior in the Sonenblum study [7] 14 of the 16 participants who were asked reported comfort/discomfort/pain as a purpose for use. Considering current knowledge about seating in the able-bodied population, it is not surprising that some wheelchair users (i.e. the multi-modal group) would use their tilt-in-space systems dynamically, more comparable to the use of a dynamic office chair, rather than solely as a device to perform scheduled pressure reliefs. Further evidence supporting the use of tilt for comfort comes from the fact that participants with sensation were more likely to move continuously while participants without sensation were more likely to have used uni-modal behavior. [7] Although comfort is generally associated with persons with sensation,[24] 11 of the 17 participants in the Sonenblum study who reported having no sensation still reported using their tilt for comfort/discomfort/pain.[7] Therefore, the issue of perceived comfort clearly extends beyond perceived sensation at the buttocks.

Effects of tilted seated postures

People who use wheelchairs with powered seating systems are sitting in their wheelchairs ~ 12 hours a day[19, 20]. A review of the literature can be used to synthesize numerous physiologic, postural and functional benefits of the use of tilt-in-space seating systems. The list includes:

- Redistribution of load off of the buttocks occurs with rearward tilt (most common justification used). [2-4, 25-29] As tilt increases, more load is redistributed off of the buttocks.
- Tilting to 20° and beyond offers significant shear reduction[4] compared to upright and recline.
- Slight improvement in lower limb blood flow at 30° and 50°of tilt has been demonstrated in persons with spinal cord injury.[30] These results may have implications for those at risk of blood pooling or edema during upright sitting.
- Small tilt ranges (upright to 15 degrees) significantly increase superficial blood flow in the ischial tuberosity region.[7]
- Improved respiration in medium (25°) and large tilt (45°) was measured in people with multiple sclerosis.[8] Improved voice volume with tilt for people with MS may allow them to be heard in times of stress/danger.
- Improved sitting balance and posture during tilt has been shown in different user groups [4, 8, 13, 14].
- Use of an adjustable tilt-in-space seating system can allow a user to alternate between an upright position for functional activities such as transferring, eating and reaching for objects and tilting back for postural support and physiologic reasons throughout the day.[16]
- People report using small and large tilt amplitudes to increase comfort and decrease pain.[7, 18] People have been found to be more productive when their discomfort is minimized.[23] If wheelchair users can spend more time out of bed and in their wheelchair, then their opportunities for participation are greatly increased.

The prescription or recommendation of tilt-in–space should consider factors beyond medical need for successful use. The environment of use, user's comfort level and means of transportation need to be discussed and pros/cons weighed. Any potential change in seat to floor height from previous wheelchair if applicable, as well as possible need to change or modify a vehicle to safely transport a wheelchair with a tilt-in-space system can and will prevent the use of the system if the change negatively impacts the users function/access despite medical need. The environment of use needs to have the necessary space in which to tilt frequently. For example, small spaces such as an office cubicle, boardroom, grocery register workspace, lab, or cluttered classroom may hinder use of the system solely due to space restrictions or even the perceived social acceptance of performing tilts in public.

Training tips for use of tilt-in-space

Research that monitored the use of tilt-in-space wheelchairs found that most users do not perform large amplitude tilts needed for pressure re-distribution.[7, 19] Since pressure relief is a primary goal of powered tilt systems, increasing its utilization is an important clinical goal. Several participants in this study mentioned that they felt a full tilt was unstable, even if they knew they would not actually tip over. Questioning in a clinic setting corroborated that finding. In addition, many users state that it is disruptive to tilt during their daily activities including routine household tasks, computer work, work functions, visiting with friends/family, religious meetings and even while watching TV. Improved specific training and education can facilitate use of the tilt-in-space system to maximize benefit to the user.

- Upon delivery of a tilt-in-space system to a new user, the clinician or healthcare professional should dedicate time to reviewing the system. Educate the user/caregiver(s) about the necessity of fully tilting to maximize pressure redistribution. Interface pressure mapping is an educational tool that can be used to demonstrate to the user the redistribution of pressure throughout the tilt range. The frequency of weight shifting reported in Pressure Ulcer Prevention and Treatment Following Spinal Cord Injury Clinical Practice Guidelines [31] is every 30 minutes for 30 seconds or every 60 minutes for 1 minute.
- The healthcare professional should take the user through the full range of tilt to instill confidence in the user and mitigate any fears about instability in full tilt. Reinforce, if necessary, that returning to a full upright position may not be a goal for all users if gravity assisted positioning is required for stability or to minimize postural deformities.
- Training should verify that the user of a power tilt-in-space system can access the tilt switch throughout the range of the system, especially when returning from full tilt. Ensure that the user can repetitively and comfortably perform the full tilt independently.
- Written instructions can be provided to the user and/or caregivers for future reference. These can include details of rationale behind pressure reliefs, frequency and duration of pressure reliefs and photographs of the full tilt position.
- A seating system that allows the tilt range to be pre-programmed can also be a consideration for users that are hesitant about using the full range of tilt or prefer to tilt back to a consistent position. This feature will tilt back to a pre-programmed position following a single activation of the tilt switch by the user. The user must be conscious of making sure enough space is available to tilt when these types of systems are used. For example, the user must back up from a table

and make sure there is sufficient space behind them before the tilt switch is activated as it is latched.

- For those who need reminding about when to tilt, a timer can be utilized. While timers have not been proven effective for all users, they are effective reminders for some users. Problem-solving with the user about incorporating tilting during his/her typical daily activities can be useful. For example, suggesting that tilting be performed during commercials while watching TV, before and after a work meeting, or before or after a meal may prove to be more practical and easier to remember than every 15-30 minutes.
- Educate the user on the benefits of using the system in the smaller ranges to improve posture and balance, comfort, decrease pain, and for rest/relaxation. The degree and duration of these types of tilts are left up to the user. The main message to deliver is that tilting can be used to positively influence user's well-being in addition to pressure relieving weight shifts.
- The tilt system can also be used for postural stability when negotiating over rough terrain or descending ramps. Tilting between 10-15° appears to be an appropriate amount. Most tilt-in-space chairs include a drive lock-out feature that prevents a user from driving if tilted too much. If this lock-out feature is disabled, additional education is needed to insure the user does not drive in unsafe amounts of tilt, considering traversing flat ground and inclines.

In summary, clinicians should impress upon users that they should use the tilt feature often. Using the tilt feature has several demonstrated benefits that cannot be realized unless users engage the tilt feature regularly. Users gain benefit from sitting at different postures throughout the day, and powered tilt in space systems afford the opportunity to do so. Finally, users should strive to tilt back as far as possible on a regular basis. Developing a routine is difficult, but important.

1. Michael S, Porter D, Pountney T. Tilted seat position for non-ambulant individuals with neurological and neuromuscular impairment: a systematic review. Clin Rehabil 2007;21:1063-74.
2. Aissaoui R, Lacoste M, Dansereau J. Analysis of sliding and pressure distribution during a repositioning of persons in a simulator chair. IEEE Trans Neural Syst Rehabil Eng 2001;9(2):215-24.
3. Burns SP, Betz KL. Seating pressures with conventional and dynamic wheelchair cushions in tetraplegia. Arch Phys Med Rehabil 1999;80(5):566-71.
4. Hobson DA. Comparative effects of posture on pressure and shear at the body-seat interface. J Rehabil Res Dev 1992;29(4):21-31.
5. Cooper RA, Dvorznak MJ, Rentschler AJ, Boninger ML. Displacement between the seating surface and hybrid test dummy during transitions with a variable configuration wheelchair: a technical note. J Rehabil Res Dev 2000;37(3):297-303.
6. Schunkewitz J, Sprigle S, Chung K. The effect of postural stress on lower limb blood flow in SCI persons. Proceedings of the RESNA 12th Annual Conference; New Orleans, LA; 1989.
7. Sonenblum SE. Biomechanical Responses to Seated Full Body Tilt and their Relationship to Clinical Application. Atlanta: Georgia Institute of Technology; 2009.
8. Chan A, Heck C. The effects of tilting the seating position of a wheelchair on respiration, posture, fatigue, voice volume, and exertion outcomes in individuals with advanced multiple sclerosis. J Rehabil Outcomes Meas 1999;3(4):1-14.
9. Kanyer B. Meeting the seating and mobility needs of the client with traumatic brain injury. . J Head Trauma Rehabil 1992;7:81-93.
10. Motloch W. Seating and positioning for the physically impaired. Orthotics and Prosthet 1977;31:11-21.
11. Nwaobi O. Effects of body orientation in space on tonic muscle activity of patients with cerebral palsy. Dev Med Child Neurol 1986;28:41-4.

12. Pope P. A study of instability in relation to posture in the wheelchair. Physiotherapy 1985;71:124-31.
13. Lalonde N, Dansereau J, Aissaoui R, Lacoste M. Effect of different tilt and seat-to-back angles on trunk, pelvic and hip orientations. Proceedings of the RESNA 22nd Annual Conference; 1999.
14. Angelo J. Using single-subject design in clinical decision making: The effects of tilt-in-space on head control for a child with cerebral palsy. Assist Technol 1993;5:46-9.
15. Janssen-Potten Y, Seelen H, Drukker J, Reulen J. Chair configuration and balance control in persons with spinal cord injury. Arch Phys Med Rehabil 2000;81:401-8.
16. Hardwick K, Handley R, Feichtinger L. The use of automated seating and mobility systems for management of dysphagia in individuals with multiple disabilities. Austin, TX: Austin State School.
17. Dewey A, Rice-Oxley M, Dean T. A qualitative study comparing the experiences of tilt-in-space wheelchair use adn conventional wheelchair use by clients severely disabled with multiple sclerosis. British Journal of Occupational Therapy 2004;67(2):65-74.
18. Lacoste M, Weiss-Lambrou R, Allard M, Dansereau J. Powered tilt/recline systems: why and how are they used? Assist Technol 2003;15(1):58-68.
19. Sonenblum SE, Sprigle S, Maurer C. Use of Powered Tilt Systems in Everyday Life. Disability and Rehabilitation: Assistive Technology 2009;4(1):24-30.
20. Ding D, Leister E, Cooper RA, Cooper R, Kelleher A, Fitzgerald SG et al. Usage of tilt-in-space, recline, and elevation seating functions in natural environment of wheelchair users. Journal of Rehabilitation Research & Development 2008;45(7):973-84.
21. de Looze MP, Kuijt-Evers LF, van Dieen J. Sitting comfort and discomfort and the relationships with objective measures. Ergonomics 2003;46(10):985-97.
22. Udo H, Fujimura M, Yoshinaga F. The effect of a tilting seat on back, lower back and legs during sitting work. Ind Health 1999;37(4):369-81.
23. Zacharkow D. Posture: Sitting, Standing, Chair Design and Exercise. Springfield, IL: Charles C Thomas; 1988.
24. Hobson DA, Crane B. State of the Science White Paper on: Wheelchair Seating Comfort. 2001.
25. Henderson JL, Price SH, Brandstater ME, Mandac BR. Efficacy of three measures to relieve pressure in seated persons with spinal cord injury. Arch Phys Med Rehabil 1994;75(5):535-9.
26. Pellow TR. A comparison of interface pressure readings to wheelchair cushions and positioning: A pilot study. Canadian Journal of Occupational Therapy 1999;66(3):140-9.
27. Spijkerman D TM, Goossens R, Stijnen T. Effects of inflation pressure and posture on body-seat interface pressure of spinal cord injured patients seated on an air-filled wheelchair cushion. Journal of Rehabilitation Sciences 1995;8(1):8-12.
28. Sprigle S MC, Sonenblum S. Load Redistribution in Variable Position Wheelchairs in People with SCI. JSPCM 2009;in press.

29. Vaisbuch N MS, Weiss P. Effect of seated posture on interface pressure in children who are able-bodied and who have myelomeningocele. Disability and Rehabilitation 2000;22(17):749-55.
30. Schunkewitz J SS, Chung KC. The effect of postural stress on lower limb blood flow in SCI persons. Proceedings of the RESNA 12th Annual Conference; New Orleans, LA; 1989.
31. Pressure Ulcer Prevention and Treatment Following Spinal Cord Injury: A Clinical Practice Guideline for Health-Care Professionals. In: Paralyzed Veterans of America, editor.: Consortium for Spinal Cord Medicine; 2000.