CLINICAL PERSPECTIVE

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CEU ARTICLE

TILT & RECLINE

UNDERSTANDING ALL THE ANGLES

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The tilt-in-space design was first conceived by Hugh Barclay, an orthotist, working with physically challenged children. He observed that skeletal asymmetries, such as scoliosis, could be supported or partially reduced with the client tilted. The first tilt-in-space wheelchair was invented in Kingston, Ontario, Canada, in the early 1980s. Tilt-in-space chairs have been utilized for more than 30 years as a means of shifting weight from the buttock to the back for pressure management.

The tilt-in-space frame allows change in a client's orientation to gravity while maintaining the same seat-to-back angle and relationship between seating components and the client. Tilt-in-space chairs have evolved from a single posterior pivot point design, requiring a longer wheelbase for stability, to the center of mass or rotational design with improved stability and shorter base requirements.

Recline systems produce a change in seat-to-back angle with an angular and linear relationship change between seating components and the client. The back pivots rearward without a change in the seat position to gravity. Basic recline manual and power chairs use a pivot point that is level with the seat rail of the chair. This promotes and increases the tendency for downward migration of the client's center of mass on the seat, as well as the migration of the torso down the back. Minimal shear systems emerged in late 1980s to address this issue using two different methods. The first design involves incorporation of a raised pivot point for the back canes that is in close proximity to the client's hip joint to reduce the shear effect. The second design, initially invented by Greg Peek, allows the back to glide downward on tracks as the seat-to-back angle opens, minimizing the shear effect. So what criteria determines the need for tilt, recline or both?

FUNDING

If the funding source is Medicare, the team must follow the algorithmic process for determining a mobility deficit as of July 2005. Mobility Assistive Equipment (MAE) includes canes, crutches, manual wheelchairs, scooters and power wheelchairs. National coverage determination states MAE is reasonable and necessary for a beneficiary who has a mobility deficit sufficient to impair their participation in mobility-related activities of daily living (MRADLs), which can include toileting, feeding, dressing, grooming and bathing in customary locations in the home.

Does the beneficiary have a limitation that impairs their ability to participate in one or more MRADLs in the home (independently, safely or timely)? In this process, canes, walkers or gait trainers are considered if the use of this device improves independence, safety and timeliness. If not, a manual wheelchair is considered based on specifics such as the beneficiary's ability to self-propel (UE strength/coordination/endurance, as well as cognitive capabilities or safety). Specific client limitations/strengths are used to justify frame specifications as well as each seating component.

A tilt-in-space chair is covered if a client meets one of the following criteria: at risk for developing a pressure injury and is unable to perform a functional weight shift, or has increased or excessive muscle tone or spasticity related to a medical condition that is anticipated to be unchanged for at least one year.

A power seating system (tilt only, recline only, or combination tilt and recline), with or without power elevating leg rests, will be covered if criteria one, two, and three are met and if criterion four, five, or six is met:

1. The individual meets all the criteria for a power wheelchair; and

2. A specialty evaluation of the beneficiary's seating and positioning needs was performed by a licensed/certified medical professional, such as a physical or occupational therapist, or physician who has specific training and experience in rehabilitation wheelchair evaluations. The PT, OT, or physician may have no financial relationship with the supplier; and

3. The wheelchair is provided by a supplier that employs a RESNA-certified Assistive Technology Professional (ATP) who specializes in wheelchairs and who has direct, in-person involvement in the wheelchair selection for the beneficiary.

And:

4. The individual is at high risk for development of a pressure

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injury and is unable to perform a functional weight shift;

5. The individual utilizes intermittent catheterization for bladder management and is unable to independently transfer from the wheelchair to bed; or

6. The power seating system is needed to manage increased tone or spasticity.

If these criteria are not met, the power seating components will be denied.

CLINICAL APPLICATIONS

Before delving into the clinical rationale and distinctions for tilt, recline or both, let us consider the possible impact of changing a client's orientation in space. Arousal, skeletal alignment, soft tissue flexibility (range of motion), skin integrity, reflex activation, tonal changes, compensatory pattern elicitation, functional access for activities or switch use, cardiopulmonary status, ingestion/swallow, digestion/elimination, perceptual orientation, visual field, and bone integrity may be affected.

Clients with a traumatic brain injury in the early stages of rehabilitation may have arousal issues as well as limited head and trunk control. Arousal occurs best in positions closer to vertical. Determining the degree of tilt to assist with postural control without diminishing arousal is crucial to progress, but tricky.

Tilt for effective pressure management has been documented in numerous research studies. In 2011, Giesbrecht, et al. in "Different Models of Dynamic Tilt in Manual Wheelchairs" measured interface pressure with single pivot point tilt and rotational axis tilt. Pressure mapping was completed at various degrees of tilt on 18 people with spinal cord injuries using the same seat cushion and model of tilt-in-space chair with the seat-to-back angle fixed at 100 degrees. The results stated at least 30 degrees of tilt are needed to produce a reduction in pressure at the ischial tuberosities (ITs) of clinical value. Ten percent tilt produced less than 5 percent reduction in IT pressure but increased load at the sacrum. Twenty-degree tilt produced less than 15 percent reduction, 30 to 40-degree tilt produced 20 percent reduction and 40 to 50-degree tilt produced a 25 percent reduction in pressures at the ITs and sacrum. Hence the authors concluded, "small tilt angles are more suitable for postural control than pressure management."

Skeletal alignment, tone and reflexive activity can change with seat-to-back angle adjustments, particularly with neurologically-involved clients. Therefore, it is critical to assess each client to avoid negative repercussions. For example, in a 2-year-old client demonstrating an extensor thrust, increasing hip flexion will overlengthen the hip extensors and reduce force generation, prevent or reduce hip extension, and allow the client to possibly develop more functional movement strategies instead of a mass pattern of extension. Hence, closing the seat-to-back angle to 85 degrees (usually with seat inclined 5 degrees) could be beneficial to promote best posture, in conjunction with variable tilt to allow pressure relief. However, if a client does not have potential for improvement in functional strategies and is using mass extension to improve inhalation (respiration), for dynamic movement or pressure relief, then a dynamic back may be appropriate. A dynamic back can provide the client momentary recline for better respiratory inhalation, while re-seating the pelvis in good alignment after the extensor thrust.

In the recline frame, skeletal alignment changes as seat-to-back angle opens, hence hip and possibly knee joint range (when elevating legrests or ELRs are also used) needs to be adequate for the degree of recline. If using the basic recline design, postural control and positioning, switch access and skin integrity may be impacted due to this skeletal shift.

A change in seating system orientation can impact perceptual orientation. Perceptual orientation is maintaining an awareness of one's position in space and time. Perceptual orientation develops from the vestibular, visual and somatosensory stimuli received through the body. Tilt and recline systems impact all three systems. The vestibular system monitors direction, speed and head placement in space in relation to gravity by way of semicircular canals in the middle ear. Body often follows head, hence providing an awareness of the body's orientation to gravity and movement in space. "Proprioception is the ability to sense stimuli arising within the body regarding position, motion, and equilibrium" (MedicineNet.com, 2016). Proprioception provides information about body schema, timing and speed of movement. Proprioceptive, vestibular, and other tactile input are critical for sensory-motor development. An individual receives sensory information and integrates it with motor systems to manage head, torso and limbs in space against gravity for a specific task – in other words, to learn effective movement strategies.

Sensory processing is the ability to synthesize, organize and process incoming sensory information and use it for purposeful activity. "Sensory Processing Disorders are impairments in detecting, modulating, interpreting or responding to sensory

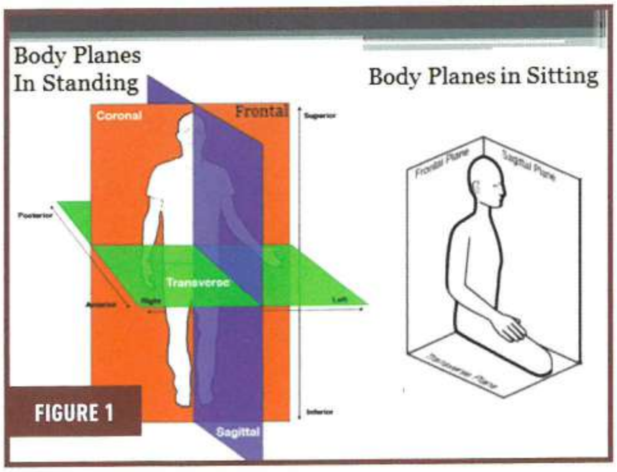

FIGURE 1

Body Planes

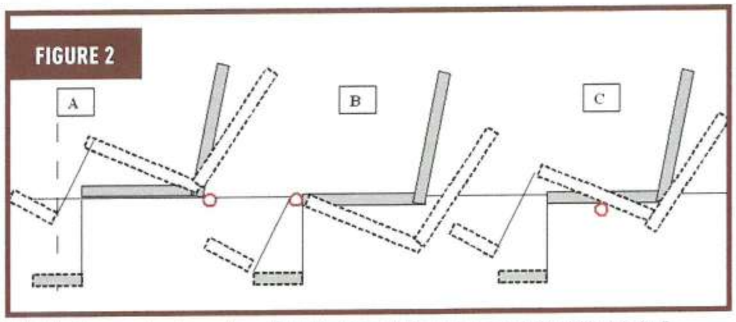

FIGURE 2

Tilt Axis Placement on Frame (from "Tilt, Recline and Elevating Legrests for Wheelchairs," 4th International Interdisciplinary Conference, Glasgow, June 2010).

stimuli" (Miller, Coll, Schoen, 2007). "Sensory modulation disorders are impairments in regulating the degree, intensity and nature of the response to sensory input resulting in problems in daily routines." (Miller 2006).

There are three subtypes under sensory modulation including sensory over-responsivity, sensory under-responsivity, and sensory craving. The easiest way to understand this is to consider sensory input with regard to threshold. Sensory input can come in different intensities. Some individuals have a low threshold and receive input earlier than the typical population. Clients with sensory modulation issues, such as low threshold tactile and vestibular, may have difficulty with recline or tilt, secondary to perceiving vestibular and tactile information sooner and with more intensity. Hence, this client may react negatively to this flood of stimuli. Reducing the posterior tilt range from 45 degrees to only 5 degrees of adjustment (through use of a split collar clamp) and gradually increasing the excursion over time may prove more beneficial and easier for the client to adapt to.

Clients with a high threshold may have difficulty knowing where their head or body parts are in space and either shut down (become unresponsive/sleep) or actively crave or seek sensory input for a time. Sensory seeking can present as banging against the back or rocking in the chair. A dynamic back and headrest on a rotational axis tilt frame will allow deep pressure to the back (tactile) and the head excursion (vestibular) needed to arouse, focus and engage this client while maintaining a stable wheelbase.

DESIGN CONSIDERATIONS: TILT

So, let's get into more detail about tilt-in-space frame design. When choosing tilt-in-space for a client, several design features need to be considered, including the plane in which the tilt occurs, the direction and degree of tilt, the location of tilt axis on the frame, single pivot vs. rotational axis, and the need for variable or fixed tilt. The plane of tilt can occur in the sagittal, frontal or oblique plane (a combination of sagittal and frontal) (See Figure 1).

The direction also can be specified – sagittal (anterior or posterior tilt), frontal (lateral tilt left or right), or oblique (multiple diagonals). Fixed tilt can be achieved in the frame design itself through adjustable hardware which attaches the seat and back to frame at a specific angle or through vertical axle adjustment on a lightweight frame.

Adjustable tilt can be incremental or infinite and is achieved within the frame design. Variable tilt frames may allow 30 to 60 degrees of posterior tilt, and possibly 5 to 20 degrees of anterior tilt. The placement of the tilt axis within the frame can be posterior (A), anterior (B), or central or floating (C) (See Figure 2).

Location of tilt axis on the frame may affect visual field, forward reach, access to the wheel for propulsion, knee excursion and frame stability. So, what clinical criteria dictate the use of specific characteristics of tilt?

Posterior tilt is often used for clientele with significant muscle weakness, limited postural control, limited ability to weight shift and manage pressure relief, feeding/swallow issues, progressive muscle disease or paralysis (Spinal Muscular Atrophy, Muscular Dystrophy, Multiple Sclerosis, Amyotrophic Lateral Sclerosis), or an acquired injury (traumatic brain injury (TBI), SCI). Posterior tilt can redistribute weight off the buttock onto the posterior torso, reduce gravity's influence on skeletal alignment, assist in maintaining an upright functional posture, aid feeding, allow pressure relief for clients with extensor spasms or extensor thrust, aid caregivers in dependent transfers, and allow head clearance through a van door.

IN, "HOW POWER TILT IS USED IN DAILY LIFE TO MANAGE SITTING PRESSURE: PERSPECTIVES OF ADULTS WHO USE POWER TILT AND THERAPISTS WHO PRESCRIBE THIS TECHNOLOGY," (L.TITUS, 2013) reviewed the literature and found the following purposes for power tilt as described by research/authors:

1. Comfort/discomfort/pain management (Dewey et al 2004, Dicianno et al 2009, Ding et al 2008, Lacoste et al 2003, Sonenblum & Sprigle 2011).

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2. Pressure management (Dewey et al 2004, Dicianno et al 2009, Ding et al 2008, Sonenblum & Sprigle 2011).

3. Management of spasms (Dewey 2004 et al).

4. Increase sitting tolerance (Dewey 2004, Dicianno 2009, Sonenblum & Sprigle 2011).

5. Manage fatigue (Dewey 2004, Dicianno 2009).

6. Maintain postural alignment (Dicianno 2009, Sonenblum 2011).

7. Improve function (Lacoste 2003, Ding 2008, Diacianno 2009, Sonenblum 2011).

8. Address physiological issues (i.e. blood pressure) (Lacoste 2003, Dicianno 2009).

9. Facilitate transfers (Dicianno 2009).

10. Provide rest (Lacoste 2003, Ding 2008, Souza et al 2010).

In this same dissertation, the author states that wheelchair users' purposes for using tilt was first and foremost for comfort/discomfort/pain management, followed by rest and relaxation, as well as function and postural management.

Anterior tilt can facilitate active hip and trunk extension to improve sitting, as well as improve forward upper extremity reach when applied to the appropriate client. Most functional tasks occur in an anterior pelvic tilt position. In the article, "Functional Seating for School-Age Children with Cerebral Palsy" (Costigan & Light, 2011), the authors explain the numerous benefits of this adjustment in the seat, including speech production, intelligibility and feeding. Mac Neela (1987) and Nwaobi & Smith (1986) have shown an anterior tilt improves respiratory function of the school-aged child and improves vital capacity and forced expiratory volume for clients with spastic cerebral palsy. Anterior tilt can also aid certain clients with muscle weakness in hip and knee extension to achieve standing.

Lateral tilt can help manage gastro-esophageal reflux and secretions, facilitate gastric emptying, accommodate severe fixed asymmetries, and aid with positioning and balance in more complex clients (See Figure 3). For example, a 65-plus-year-old male with a non-operable dislocated hip is unable to sit without pain. Using a lateral tilt provides the client opportunity to sit intermittently for social engagement, eating and brushing his teeth without pain.

Oblique tilt, which is a combination of tilt in both the frontal and sagittal planes, can also aid management of gastroesophageal reflux and facilitate gastric emptying, assist with digestive absorption issues related to skeletal malalignment, accommodate severe fixed asymmetries and promote a righting/equilibrium response to strengthen trunk musculature, when possible. Severe skeletal distortion impacts both thoracic and intra-abdominal cavity pressures which, in turn, affect stomach emptying, gastroesophageal reflux, absorption in the small intestine, and peristalsis which can lead to constipation/elimination issues. Both oblique and lateral tilts have been shown to aid with these issues.

Tilt axis placement can be critical when posterior tilt is necessary. If the axis placement is located too posterior on the seat rail, certain situations can displace the client's mass posterior in the frame and potentially reduce stability, even leading to posterior tipping of the frame. These situations include clients who are obese, have extensor spasms, who "bang" against the back canes or even hang heavy backpacks on the push handles. The central axis tilt frame maintains the client's center of mass within the center of the frame, promoting stability even in full rearward tilt (See Figure 4). This configuration produces a smaller footprint for greater accessibility and maneuverability for caregivers. Also, less weight is transferred to the casters when upright, reducing the energy required to push the chair and reducing caster repair issues.

Placing the tilt axis posterior in the frame design causes significant knee elevation during tilt, limits forward reach, lowers the sight line, and shifts center of mass posterior in the frame as discussed above. Placing the axis anterior within the frame design also lowers the sight line and limits forward reach and possible access to the wheel for independent propulsion, but knee height remains fairly constant, which proves beneficial for table and sink accessibility. This approach is frequently used in long-term care facilities to allow clients to access table and sink heights in an institutional setting.

DESIGN CONSIDERATIONS: RECLINE

Seat-to-back angle adjustments refer to changes between the superior aspect of the seat and the anterior aspect of the back. Recline systems provide a change in position by allowing the back to pivot rearward without a change in the orientation of the seat. This pivot point is located lower on the seat rail of the chair rather than in alignment with the client's hip joint. Adding a seat cushion further compounds the problems by adding more distance between the person's pivot point (hip joint) and the frame's pivot point.

Shear results as the back support moves against the person's skin. Standard recline

FIGURE 3

Lateral Tilt

FIGURE 4

Central Axis Tilt Frame (Convaid)

has the potential to reduce perpendicular pressure by redistributing body weight over a larger surface area; however, the movement of the backrest leads to shear. Shear is the parallel or tangential force between the user and the seating surface, caused by two forces acting in opposing directions. Shear deforms tissue, and when present with perpendicular force, can accentuate skin damage. Friction between the client and the back limits movement between these two surfaces, resulting in heat and abrasion. Presently, what frame designs are available to manage shear? In the mid-1980s, several power wheelchair manufacturers were aware of the negative effects of shear and began implementing design changes. The incorporation of the raised pivot point for the back canes was one solution. Displacement of the back support surface against the client, either through the use of a manual sliding back mechanism or power sliding back, also helped to reduce shear. LaBac Systems and Motion Concepts were two of the pioneers in these designs.

So, what are the clinical rationale and ramifications for the use of recline? Modifications to the seat to back angle can affect cardiopulmonary function, skeletal alignment, postural control and function, manual reach, visual field, and transfer capability. Indications for a seat-to-back angle greater than 90 degrees (95 to 180 degrees) include hip flexion limitations, respiratory compromise, skeletal asymmetries, comfort, fatigue, postural hypotension, venous return insufficiency (when used in combination with ELRs), G-tube feedings, diapering, tracheostomy care, pressure concerns, urinary catheterization, bowel care and maintaining range of motion.

Power seat functions, specifically recline, may effectively assist a client with positioning for bowel/bladder care to increase independence, be it for intermittent catheterization, bowel care or preventing line crimping in an in-dwelling catheter. Using only tilt with indwelling catheters can sometimes lead to urine retention and backflow. History of frequent urinary tract infections or hydronephrosis of the kidneys are risk factors. Hence, a written descriptive of bowel and bladder care would be needed in the justification letter.

One issue at the top of caregiver burnout is bowel and bladder management, as well as transfers for this activity. Effective justification could produce tremendous positives in this situation. Orthostatic or postural hypotension requires the client to quickly recline to normalize blood pressure. Venous return insufficiency can also be an indicator for recline with elevating leg rests. The legs must be 30 cm above the left atrium of the heart to facilitate improved venous return. Contraindications for recline alone may include limited hip and knee extension, obligatory primitive reflexes or tonal changes, skin integrity issues, and loss of functionality in postural control, forward reach and vision.

DESIGN CONSIDERATIONS: COMBINATION TILT AND RECLINE

Tilt and recline are often used together in power mobility for clients with SCI, ALS, MD, MS and cerebral palsy. The benefits of combined tilt and recline include better pressure relief; multiple postural adjustments to increase comfort, decrease pain, increase sitting tolerance and functional position for tasks; aiding physiological systems (cardiac, respiratory, gastrointestinal and renal) for improved respiration, blood pressure and bowel/bladder management; easing caregiver transfers; and management of ROM and spasticity. In 2001, Aiassaoui et al. concluded that tilt and recline combined reduced pressure more than tilt-in-space alone. In 2010, in the "Effect of Wheelchair Tilt-in-Space and Recline Angles on Skin Perfusion over the Ischial Tuberosity in People With Spinal Cord Injury," researchers measured skin perfusion in 11 wheelchair users with C4- T 12 SCI and no pressure injuries. There were six protocols used: 15-degree, 25-degree and 35-degree tilt with 100-degree recline and 15-degree, 25-degree and 35-degree tilt with 120-degree recline. Each protocol consisted of two, five-minute periods: one period of five minutes sitting-induced ischemia

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and a second five-minute period of pressure relief through a combination of tilt and recline. A five-minute washout period was allowed between protocols (at 35-degree tilt and 120-degree recline).

Results showed at least 35-degrees of tilt with 100-degrees recline or 25-degree tilt with 120-degrees recline were needed for significant increase in skin perfusion at the IT area. In "Effect of Durations in Wheelchair Tilt-in-space and Recline-on-Skin Perfusion over the Ischial Tuberosity in People with SCI (2013)," Jan, Liao, Jones, Rice and Tisdell found that a three-minute duration weight shift was necessary for best skin perfusion when combining a tilt of 35-degrees and recline of 120-degrees. At one minute, skin perfusion was not adequate with this combination. So, does the present standard for pressure management need to be changed? According to the Consortium for Spinal Cord Medicine (2000), a tilt should be performed every 15-30 minutes for one minute, with tilt angle not yet defined but between 30 to 65 degrees.

Researchers Ding, Leister, Cooper, et al. (2008) in "Usage of Tilt-in-Space, Recline and Elevation Seating Functions in Natural Environment of Wheelchair Users," monitored 11 users (18-70 years of age) with diagnoses of CP, SCI, MS, MD for two weeks in their natural environment and found they used small angles (less than 20-degree tilt and less than 110-degree recline) intermittently throughout the day. Large angles of adjustment were rare. Tilt (64 percent) and recline (76 percent) were used at separate times during the day, as well as in combination (39 percent) with rationale for adjustments being comfort, postural stability, and reducing interfacing pressure. Very little time was spent in a fully upright position (0.6 +/- 1.5 hours per day). The four subjects with SCI and three subjects with MS had limited trunk control, making upright posture both challenging and fatiguing – hence the frequent use of tilt for postural control.

In summary, wheelchair frame design has evolved over many years, particularly regarding recline – from the basic recline model to the minimal shear systems available today. Within a mere 35 years, tilt has evolved from the single pivot point to the rotational axis pivot, as well as other design features which have benefited multiple individuals to aid pressure relief, skeletal alignment, postural control, feeding, stomach emptying, and gastro-esophageal reflux, to name a few.

Research in recent years has demonstrated the importance of combining tilt and recline for clients with such diagnoses as ALS, SCI, MD, and MS for better pressure relief and frequent positional changes for comfort, increased sitting tolerance and functional tasks. Research with wheelchair users in the natural environment showing frequent use of small tilt and recline angles and rare use of 45 to 60 degrees of tilt for pressure relief, is both insightful for equipment manufacturers and clinicians. For clients to benefit from positioning technologies, seating professionals need to understand and remain up to date on the technology themselves, effectively match product to client need and clearly justify the specific product specifications in documentation.

CONTACT

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