HEALTHCARE INNOVATIONS AUSTRALIA

Postural Challenges and Seating Solutions

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What Should the Back of a Seating System Provide?

The back of a seating system is arguably the most important part of the seating system, but often receives the least attention. Maybe this is because for too long we have referred to it as a Back Rest. That's just been a cop out; in most cases it's a back support. Back supports need to accommodate a lot of individual variables. First, we need to understand what these variables are and what the needs are. Only then can we discuss how back supports can accommodate specific issues. This involves an assessment, and this is often not done.

With the back section of a seat we are looking, on the one hand, to provide support, but, on the other, allow freedom for function and activity of the user. We are trying to defy the distortional pulls of gravity while allowing freedom of movement. The 3-dimensional flexibility at each vertebra needs to be managed, while also using the back to help control the 3-dimensional flexibilities of the head, shoulder girdle, and pelvis.

Each of these aspects can present prescriptive conflicts and dilemmas. What is best for the end-user cannot always be achieved, and frequently there is a need to find a compromise. Before that point is reached, all the possibilities for producing the perfect solution should be explored, even though this may take some time and exploration. The principles outlined below are generally as equally valid for 'static' as for 'active' seating systems.

Zones of the Back

Anatomically we have designated different zones to the spine, and we should consider the different attributes of these different zones as we work our way up (or down) the different zones of the back support.

Just as the developmental process moves proximally to distally (from the trunk outward) so we need to follow that process as we work with the body. (Babies learn to roll (moving the trunk, proximal control) before they learn how to use their hands purposefully or before they learn how to walk.)

Support and space at the Pelvic level

Stability at the pelvis is important for control of both lower and upper parts of the body. To give optimal control of the pelvis in the posterior direction, it is important to provide firm support, or 'block', at the level of the PSISs. Provided that the seat cushion and postural support belts control the pelvis and prevent it from sliding forwards, the pelvis can be controlled to avoid 'posterior tilt', but still allow anterior rotation to permit functional forward reach.

Good lateral support at the level of the pelvis will reduce the risks of pelvic obliquity and rotation, with subsequent development of unnecessary degrees of scoliosis. The part of the back support level with the pelvis below the PSISs needs shaping to allow for the volume of the soft tissues of the buttocks, otherwise any pelvic block will not be able to operate.

The Lumbar space

The lumbar region is the trunk of the vertebral tree. This is where the vertebrae are the chunkiest, and they are the least flexible as a result. Within the back support, it is possible to fill the gap created by whatever degree of lordosis exists, but do not confuse this space-filling with the role of a firm PSIS support. Putting a firm support in the lumbar area only tends to push the individual forward as they relax into the support, and this cancels out the benefits of the rest of the seating system, whereas a firm support at the PSISs helps to reduce the posterior rotation of the pelvis.

Thoracic Control

The thorax is the area of the torso where most control can be exerted through the bones of the clavicles and rib cage, with least risk of damage to soft tissues.

It is equally important that space is created posteriorly for the scapulae, and for freedom for movement of the shoulder girdle.

Consideration needs to be given when applying laterals to the curvature of the rib cage (See Figure 2), especially when the curvature has been accentuated as the result of scoliosis. Laterals where the support face pad can be adjusted in three dimensions will be more effective in offering postural support and minimising pressure problems at the pad-body interface. Anterior thoracic supports (e.g. chest and shoulder harnesses, shoulder retractors, etc) can be supplied that are either fixed or dynamic. Either way, they should only be attached to a tall back where the top of the back is level with the top of the shoulders. It may be necessary to accommodate a thoracic kyphosis, if it is either fixed or is occurring naturally.

Posterior Support

The back of the seat is a support surface, first and foremost. This support is there for safety, to stop us being pulled backwards by gravity, and to help us to relax the muscles we would otherwise need to keep the torso vertical and the head in the midline. An appropriately designed back support will assist in taking some of the body's weight, thereby helping to take some pressure off the ischial tuberosities and sacrum.

Lateral Support

The torso is being pulled sideways by gravity as much as it is being pulled backwards or forwards. Lateral support built into the back system, or by secondary lateral supports, helps to provide lateral stability, but the design and placement of these devices is important to permit maximum freedom of movement. Adjustable laterals can initially help to stop scoliosis worsening, but ultimately can be used to help reduce the degree of 'flexible' scoliosis, by regular adjustments. Asymmetrical placement of lateral supports is often needed to achieve the best results.

Direction of Support

When considering where to place a support or 'block' in a seating system, angles are very important. Most seating systems encourage placement of these secondary supports in the vertical or horizontal plane. However, many of the movements or tendencies we are trying to control are at an angle, or are oblique (such as in pelvic obliquity or with scoliosis). This means that the forces can have a horizontal component or 'vector', as well as a vertical one. Thus, if we block just the horizontal component, this will redirect the horizontal component of the force into the vertical direction, making the obliquity worse! The conclusion of this is that placing any pads in the line of the force, or in a position to redirect forces into the required direction, is important. Please also remember that a redirected force vector will also have an impact on the integrity of the soft tissues of the skin as any angular forces will be increasing the risk of shear damage to the cells and tissues of the skin. (See Figure 2)

Figure 1a

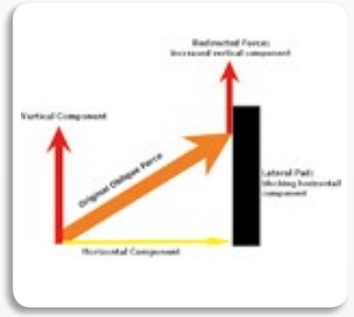

Figure 1b

Figure 2

Head Control

Getting the head into the correct alignment is probably the most important function of a seating system as this enables an individual to get on with the functional activities of life, and to interact socially. The degree of intervention needed will depend on the state of different muscle groups from the abdomen upwards. Also, and of equal importance, is the rate of onset of fatigue experienced by the individual. Minimal support may be OK for 30 minutes, but over a longer period broader support may be needed.

There are circumstances where a simple head restraint to prevent whiplash in a powered wheelchair, for example, is all that is needed, whereas a head rest may be needed to support the head in a tilt in space system, or a head support which also helps keep the head in a midline position. The latter is important where the individual's muscle strength is insufficient to fight the pull of gravity over an extended period.

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Design for Function

Facilitation of activity

A seating system should be designed to facilitate and optimise function for the individual. What that function is, will, of course, depend on the individual, and the type of activity. A balance needs to be found between providing support for the body, while minimising restriction of the individual's access to his/her day-to-day activities. Often, **subtle** lateral support devices are a better means of achieving this than the larger scale central pads on, say, a deep back.

Consideration also needs to be made to cater for different activities during the day. The ideal seat-to-back angle, as well as the optimal seat pitch or 'dump', will differ between what is best for the optimal positioning for relaxing, self-propelling, etc, and that best adopted for eating, working at a computer, transfers etc.

Anti-gravity - Prevention vs Cure

As discussed earlier, supports built into the back system are there to protect against the distorting and disabling forces of gravity. The long term effects of distortion of the spine have influences on respiration, digestion, cardiovascular function, and pain. Prevention is better than cure.

Comfort and Aesthetics

Research carried out in the United States.[1] has shown that from a user's point of view, the most important aspect of their seating system is Comfort. Comfort, though, is a subjective measure, and for some this will mean softness, while for others this could be firm positioning, breathable surfaces (wicking away sweat or heat), more body contact vs less body contact, etc. Any part of the seating system should be aesthetically pleasing, and enabling by design.

Adjustability

The range of adjustments that can be made when installing a back, and maybe later when the back is in use, will be important for providing the user with a back that is positioned correctly. For those users with existing spinal deformities, there needs to be the means to adjust the system to accommodate these 'shapes'.

However, once any adjustments are made, they need to hold and not slip out of the required position. There may be needs to adjust to different clothing for inside vs outside, summer vs winter, etc

Crashworthiness

There are ISO standards of relevance. ISO16840-4 covers 'after-market' seating systems tested on a surrogate wheelchair base, while ISO7176-19 is used to test a wheelchair with its integrated seating system. These standards look at the security of the hardware, and its risk of failing, but also look at how well the systems keep the body within a prescribed area. Thus, a low or mid length back is unlikely to pass a crash test, and be 'crashworthy', since there is not enough support of the upper torso to control rearward excursions of the upper body during the crash impact. For transportation, therefore, you are likely to need to use a tall back. There are parallel standards which cover the testing of wheelchair tie-down systems.[2]

Symmetry

Symmetry is frequently the goal of a seating system, but in reality few of us are actually symmetrical. For some individuals, for example with athetoid cerebral palsy, an asymmetric position can provide improved control of the extremities, and therefore better function. However, while allowing the individual to attain this asymmetry when needed, the seating system should also be designed to invite the body back into a symmetrical position when relaxing.

Technical considerations

Last, but not least, we need to consider practical issues. Most modern back systems have a single point of mounting on each side, since the furniture on the chair frame makes it difficult to find space for four points of attachment Ideally the back can be adjusted with the user in situ, and a requirement for only one Allen key that fits all the belts makes life easier!

When the back needs to be removed, for example to fold the chair, can this be done single-handedly and simply? Is the unit light-weight and easy to handle? Do the materials of the upholstered parts meet the flammability tests of ISO7176-16? The changes to this standard which has recently finished going through the international voting processes have been to ensure the standard is relevant to the needs of a person in a wheelchair, rather than the former furnishing upholstery basis.

[1]Crane, et al (2004) Development of a Consumer-Driven Wheelchair Seating Discomfort Assessment Tool (WcS-DAT), Intl J Rehab Res 27: 85-90

[2]International Best Practice Guidelines (2012) BPG1 Transportation of People Seated in Wheelchairs - www.pmguk.co.uk/bpg-transportation-comment.html

Specific Clinical Challenges, and Seating Solutions

In this section, different aspects of clinical presentation are looked at in note form from both a neuromuscular and an orthopaedic angle, common functional causes listed, then assessment pointers, concluding with some biomechanically oriented solutions to the clinical and seating challenges. More than one of the aspects may be exhibited by one individual.

Trunk Asymmetry, Side Flexion, and Rotation

Neuromuscular presentations

- Asymmetrical muscle tone
- Asymmetric Tonic Neck Reflex (ATNR)
- Gallant Reflex
- Rooting Reflex
- Asymmetrical functional tone

Orthopaedic presentations

- Fixed spinal deformity
- Asymmetry
- Pelvic obliquity
- Pelvic rotation
- Subluxation/dislocation of hip
- Surgical removal of head of femur
- Thigh length discrepancy
- Windsweeping

Functional causes

- Sling seat
- Base of chair too wide
- Arm supports too low
- Drive controls badly positioned
- Functional demands e.g. reaching for drive controls
- Leg length not accommodated on one side (seat too long on that side)
- Badly positioned foot supports
- Poorly positioned head support
- Badly positioned head switches/ facial pads
- Poorly positioned lateral supports

Assessment pointers

- Check position of head in relation to an ATNR
- Check set up of chair including width of chair, position of foot supports, height of arm supports, position of laterals
- Check the position of head support, head switches, and facial pads

Solutions

- Pelvic positioning belt to take pelvis as far as possible into neutral and block lateral movement of the pelvis
- Curved lateral trunk supports – these may need to be offset
- Chest or shoulder straps
- Accommodate for fixed deformity
- Ensure that head support is assisting with midline head positioning

Trunk Flexion

Neuromuscular presentations

- Trunk hypotonia
- Tonic Labyrinthine Reflex (TLR) - prone response
- Symmetrical Tonic Neck Reflex (STNR) flexion or extension response

Orthopaedic presentations

- Kyphosis
- Posterior pelvic tilt
- Hip flexion contractures
- Fixed kyphotic spinal deformity
- Hip ROM deficits

Functional causes

- Sling seat
- Seat depth too long
- Back support upholstery slack and needing tightening
- 90 degree seat to back angle leading to chronic fatigue in effort to maintain upright posture

Assessment pointers

- Determine flexibility of spinal curve and pelvic hip position
- Determine if deformity is fixed/flexible
- Review set up of wheelchair, paying special attention to seat depth, seat to back support angle, foot supports, height of arm supports, and position and angle of head support

Solutions

- Tilt in space
- Provide firm bases to seat and back support
- Open seat to back support angle to encourage trunk extension
- PSIS block, lumbar support, scapular relief
- Accommodation of fixed deformity
- Allow for posterior thoracic curvature
- Provide anterior trunk support, e.g. chest straps, shoulder straps, curved trunk laterals, tray, shoulder retractors
- Ensure appropriate position of head support

Trunk Extension

Neuromuscular presentations
- Hypertonia
- Extensor thrust
- Tonic Labyrinthine Reflex - supine response

Orthopaedic presentations
- Abdominal weakness
- Fixed spinal lordotic deformity
- Hip extensor contractures

Functional causes
- Back support too upright resulting in an increased effort to keep head up (see Cervical Flexion)
- Seat to back angle too open
- Lack of distal control, such as adequate foot positioning
- Ineffective pelvic control

Assessment pointers
- Review functional strength
- Review seat to back angle

Solutions
- Provide adequate pelvic control with possible lateral support or wedging of the seat
- Provide for scapular protraction with the contouring of the back support
- Close seat to back angle to break extensor reflex
- Accommodate any fixed deformity

Shoulder Girdle - Retraction/Abduction/External Rotation

Neuromuscular presentations
- Tonic Labyrinthine Reflex TLR
- Extensor thrust
- Asymmetric Tonic Neck Reflex ATNR
- Spasticity in scapular retractors
- Trunk hypotonia (instability of upper trunk causing 'fixing' of shoulder girdle for stability)

Orthopaedic presentations
- Muscular imbalance

Functional causes
- Instability of upper trunk
- Inappropriate manual propulsion
- Thoracic support too far forward
- Tray too high
- Orientation of back support inappropriate – system too upright where client is having difficulty maintaining upright posture because of reduced strength or low tone

Assessment pointers
- Review position of head relative to ATNR and TLR
- Review seat for appropriate positions of control points of stability
- Review orientation of wheelchair/seating system

Solutions
- Anterior chest support
- Rounded contour to the back support
- Elbow blocks

Shoulder Girdle - Protraction/Adduction/Internal Rotation

Neuromuscular presentations
- Symmetric Tonic Neck Reflex (STNR)
- Tonic Labyrinthine Reflex - prone response
- Spasticity in scapular protractors usually accompanied by shoulder adduction, elevation, flexion, elbow flexion

Orthopaedic presentations
- Kyphosis
- Reduced trunk strength
- Reduced neck strength resulting in poor head control and forward drop of head allowing contracture of muscles at front of neck and thorax
- Contractures of thoracic and abdominal muscles and fascia

Functional causes
- Orientation of seat in space (seat being tilted too much when client wishes to move to an upright position)
- Posture too upright for client with weakness or low tone to maintain position
- Anterior shoulder supports stimulating protraction
- Arm supports too low
- Tray too low/non-existent
- Drive controls too far forward

Assessment pointers
- Review position of head relative to ATNR and Tonic Labyrinthine Reflex
- Review best positions for anterior supports
- Review orientation in space for STNR and TLR
- Review contour of back to ensure fixed deformities are being accommodated
- Review position of arm supports
- Review position of drive controls

Solutions
- Check and if necessary correct chair set up
- Scapular relief by allowing more space
- Accommodate for fixed deformity with foam inserts or cut outs
- Tray to encourage more upright posture
- Tilt in space facility that allows reduction in tilt when more upright position required
- i2i to support head and encourage balanced strength of neck muscles and prevent head pulling shoulders forward.

Lateral Curvature

Here we have a lateral curve in the trunk and another one in the cervical area.

Physical Cause:
- Scoliosis
- Pelvic obliquity
- Pelvic rotation
- Hip subluxation/ dislocation
- Head of femur removed surgically
- Stroke/CP

Functional cause:
- Long term incorrectly seated or supported
- Inappropriate/ unsupportive back support
- Chair too wide
- Arm supports too low
- Foot supports set wrongly

Solutions:
- Check chair set up
- Adjust the seat cushion to help bring the pelvis into neutral
- Get pelvis as close to neutral as possible
- Use a supportive tall back support to shoulder level
- Off-set laterals with curved pads supporting the thorax via the rib cage
- Shoulder harness
- Choice of head support which will offer sub-occipital support as well as occipital support and bring the head into midline.

Tip:
Tilt-in-space can do wonders for re-orienting the effects of gravity on an anterior or posterior curve, but the same thing can be considered when looking at a lateral curve. Lateral tilt can be extremely effective in reducing the ill-effects of gravity on a lateral curve. Even a few degrees of lateral tilt can greatly reduce the adverse effects of gravity. A further benefit is that the shoulders are now more levelled and the head is much more centred and balanced.

Cervical Extension

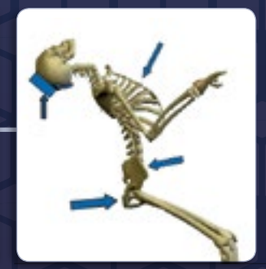
Cervical extension is likely to involve at least some degree of capital extension and is generally associated with extension of the trunk and spine, if not the whole body. In order to control cervical extension the overall extensor pattern and pelvic and thoracic postural supports must be taken into consideration. Rarely do you have pure neck extension without trunk involvement.

Solutions:
- Closing the seat to back angle may help to break the extensor pattern
- Seat depth and foot support anterior/ posterior position should accommodate hamstring length.
- Anterior support of the trunk and shoulders is required. To achieve this a properly supportive back support against which the anterior support can work, is essential.
- Sub-occiptial support and occipital support of the head to control extension is necessary.
- A slightly forward tilt of the head by the head support may help to break the extensor pattern.

Cervical Extension with Capital Extension

Generally a result of total body extensor tone with hyperextension of the trunk/spine.

- Therefore the pelvis needs to be stabilised and controlled
- A firm back and shoulder support are required
- Thoracic retraction imperative
- Pressure applied behind the occiput required for correction
- Sub-occipital support to correct capital extension



Cervical Flexion

To manage cervical flexion, the supports needed to deal with the head falling forward are:

- A tall back support for shoulder retraction straps to work against (Shoulder retraction should be backpack style)
- Cervical and occipital supports
- An anterior head support (depending upon individual – a fixed deformity may need a static pad because of trying to support the weight of the head against gravity)
- Tilt and angulation of entire seating system can re-align gravitational pull to a positive advantage.

Cervical Flexion with Capital Extension

In this we see the whole head falling forward with the face raised to the vertical. From the side one can see there are two separate curves, one is anterior, the other posterior. This is a difficult challenge to deal with. First, determine how much correction is possible. If this has been a long term position, often the neck extensors have shortened to the point where only limited correction is possible.

A. Assuming tight neck extensors, starting with the lowest curve, (cervical flexion), we would like:

- Shoulder retraction,
- Posterior support at the mid cervical level
- Anterior support high on the cervical spine.

The latter is not practical in reality. So without the addition of the anterior support, gravity is still working to pull the head into increased cervical flexion.

B. The higher curve (capital extension) needs support

- Posteriorly on the mid cervical level (same as other curve)
- Posteriorly at the occiput
- 'Anteriorly' on the neck

Ideally want 'Chin Tuck' to bring head back (decreasing cervical flexion) to neutral (eliminating capital extension). The line of force to do that extends through the mandible (at an angle from the chin through the ears).

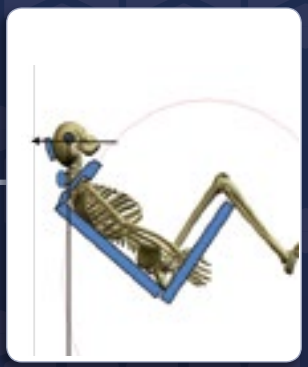
The structure of the joint does not allow for direct pressure. Gravity continues to work against us. We therefore need to revert to option C:

C. By using tilt in space, we can then use gravity positively, pulling the neck into more cervical flexion, but is now holding the head in a corrected position. At the same time, this provides support for correction of the capital extension. Create an imaginary line extending from the chin through the ear and you can see how much tilt would be required to neutralize the adverse effects of gravity.

Use sub-occipital supports to help maintain the corrected position, and prevent the increased gravitational pull on the occiput leading to the neck extensors creating more capital extension. These cannot provide correction, but you can use the supports to block movement or deterioration.

Don't underestimate the effects of gravity over time. It creates deformity, but it can also be used to decrease it.

The need for pressure anteriorly on the neck is something we cannot provide with hardware. We must use gravity.



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