The sum of the total:

The importance of position, stability, variation, and skin protection in the wheelchair

It is challenging enough to age well when not being depending on a wheelchair. How do we avoid sitting too much at work, avoid repetitive strain on the body, eat well, get enough exercise, perform our daily life activities, create a social life etc.

What are the challenges when being restricted to sit in a wheelchair between 8 and 12 hours a day as being a comfort or power wheelchair user? Which challenges do active wheelchair users face during the day - though seated for less amount of time in the wheelchair, but at the same time also seated at alternative places and chairs?

How can we age well with a disability? Have you ever tried to imagine what it would be like being a comfort wheelchair user when you must sit for say 8 hours in one stretch? When you need help to change position, help to go to the toilet and help to perform daily tasks like eating, drinking, brushing your teeth, visiting friends and family. Or have you thought about how it will be to sit in various chairs but not having strength in your lower limbs, having less muscle tissue and less sensibility, and therefore not receiving the feedback from your nervous system when you are damaging your skin?

There are 4 main factors which we can influence to make it easier to age with a disability in a wheelchair and these factors are **positioning**, **stability**, **variation,** and **skin protection**.

In the following article we have tried to explain why these factors are so important and have tried to keep it on a level where it involves different types of wheelchairs weather it's a power, comfort, and active wheelchairs.

Positioning

At first, we need to find the best seating position. This means the correct position for the whole body. The correct position of the **pelvis** is a key area for the good seating position; the pelvis will then guide the spine above. We will always try to have the eyes in the correct position and **the head balanced** in the neutral position so functions as breathing, swallowing, talking and communication are optimal. This counts for all types of wheelchairs.

As presented at the International Seating Symposium ISS 2022, any structural, physiological or neurological disturbance in the swallowing process may cause dysphagia. Each of these 4 phases can be influenced by seating and postural interventions. (The Link Between Dysphagia and Posture, Bart Van der Heyden / Filipe Correia)

Some wheelchairs require that 2 different seating positions can be achieved. One position to rest and one active position to enable the user to be social, mobile, to propel the wheelchair and to be able to use the joystick or controller.

A comfort wheelchair user will be dependent on the correct upright position to be social and needs the tilt and recline position to rest.

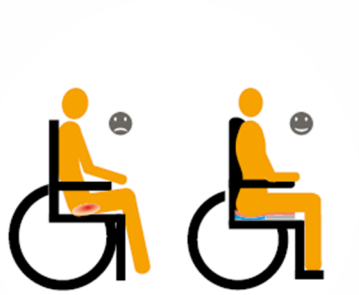
An active wheelchair user will need good posture in the wheelchair to e.g., work at a table/desk but requires a different angle of the upper body to be able to produce power to propel the wheelchair.

Having professional help to have the wheelchair **adjusted to the user** with all needed functionalities is important. Having a wheelchair which can be adjusted, and which has the proper number of accessories available to create this position(s) is of course crucial to create an optimum seating solution.

This correct seating position will help to create the most **optimal load** to the body and in that way avoid muscle skeletal pains and discomforts, stimulate cardiovascular and respiratory function, maintain circulation, avoid negative load on the digestive system and protect the skin in an optimal way while having access to the required functionality.

Stability

The next challenge is to maintain the achieved correct seating position. We need to create stability at the areas where the wheelchair user cannot create sufficient stability on its own.



The **primary position and stability** will be created with the standard parts of the wheelchair:

- Leg supports
- Seat and seat cushion
- Back and back cushion
- Head support
- Arm support

Secondary position and stability can be created by adding accessories like a tray, side supports, a hip belt, a harness etc.

The amount of external stability needed is depending on the internal stability of the user.

An active wheelchair user with a low spinal cord injury (SCI) can have the required core stability to sit upright and to move the upper body and, in that case, will often prefer a low back which allows him or her to be mobile enough to propel the wheelchair to reach in all directions etc. Stability and mobility are always influencing each other. Having les stability means being les mobile.

A comfort wheelchair user with deformities will need external stability to stay in the correct position, so **side supports** to keep the body from falling to one side can be indicated. A harness could be indicated to avoid too much kyphosis.

A power wheelchair user who sits many hours in the chair and uses the chair to be mobile and independent could need a moulded seat to create the stability needed to drive the wheelchair, work at the desk etc.

Please keep in mind that we always need to look at the whole body and all the functions needed. Many active wheelchair users will e.g., use a hip belt to create more stability when propelling their chair while they would not need it when sitting at a table/desk. A comfort wheelchair user could need a harness to avoid too much kyphosis.

Creating stability with the primary position tools

Support the legs

The first element to look at when creating position and stability is the leg supports. The leg supports need to be placed correctly and adjusted to support the feet. Remember, that many wheelchair users have short hamstrings, which will influence the position of the pelvis. When **short hamstrings** are involved, 90 degree or less angled leg supports are highly indicated to give the best support for the user and prevent sliding. Please

keep in mind that the starting point is not always the feet, but can be the seat, or at more rare occasions other areas.

If you would like to know more about the importance of correct positioned leg supports, please have a look at our article dedicated to this topic: “Why leg supports are so important” (www.My-Netti.com).

It is a pity that at most seating challenges, the leg supports are not paid more attention at when there is a hyper kyphosis involved. Let us look at all areas of importance at the leg supports and why this is important.

At first it is important that the knees can have a relaxed position which means for most people a slightly outward rotation in the hips, resulting in the knees being in position which is wider than the hips. Many leg supports are too narrow at the knees, and block this slightly outward rotation in the hips. This leads to a tension building up towards more kyphosis.

Please do the following experiment: sit on a chair and move your knees away from each other and afterwards towards each other. Notice the following: The external rotation in the hips when you move your knees away from each other, will stimulate for the external rotation at the upper extremities and “open up” the chest area and stimulate extension in the spine. Moving the knees towards each other will rotate the hips inwards, close the chest and stimulates for unwanted flexion. Think about the position we had when being a foetus before being born, when we were a baby curling up. It is all about flexing and creating inwards rotation.

The second point to look at is where the feet are placed on the leg supports. Will it be possible to have an almost 90-degree flexion in the knee joint or not, while the feet have a stabile surface to stand on?

If the feet cannot be placed with the knees in about 90-degrees, the user will after a while starting to “search” for this 90-degree position since this creates least tension to the soft tissues. So, when the 90-degree position cannot be created, the user will start adding pressure to the calf supports to reach and search for the 90-degree position and in this way pulling themselves forward on the seat cushion. When this happens, the pelvis loosens its position and the user starts increasing the pressure under the seat bones, increasing the shear forces and starts sliding out of the wheelchair.

At third, many users with a hyper kyphosis also have short hamstrings. When the hamstrings are short it is important to take as much as possible tension away from these hamstrings to avoid that the hamstrings pull the pelvis in a posterior tilted position. A posterior tilted pelvis will increase the pressure under the seat bones, increase the shear forces and in this way increase the risk for pressure injury and the user will start sliding out of the wheelchair.

All wheelchairs should have the option to place the feet of the user in a less than 90 degrees angle to avoid the tension of the hamstrings pulling the pelvis out of position, prevent decubitus, and prevent pain and discomfort due to incorrect position of the user.

Stability at the seat

Stability at the seat can be created by choosing the right **seat plate** as well as the correct **seat cushion**. To accommodate for the different need for stability, our wheelchairs are offered with a diverse level of options. With the different configuration options of each chair, we can ensure extra pelvic and trunk stability when needed and thereby minimize risk of sliding and shear forces.

A shaped seat plate and a multi-layer cushion with different layers of various material, can help to position the pelvis better and maintain position.

Stability at the back

This can be created by the choice of **back systems** and **cushions**. Creating more space for the thorax to penetrate the back cushion will solve a lot of seating challenges for users with large kyphosis. A higher level of stability at the back together with the correct seating positioning, can help to distribute the pressure at the back to areas where this is tolerated well. In that way pressure on more sensitive areas as the seat bones and pelvic floor can be reduced.

Arm support

The height, length, width, choice of upholstery, and position of the arm supports are important areas to optimize and can create extra stability for the user. Keep in mind though that this way of creating stability is not a good one in the long run if this is the only part of the chair supposed to create stability in the body/trunk. Having the user to stabilize themselves on their elbows is creating a high load on the shoulder and neck area and will lead to discomfort. In cases like this, it is better to create the stability at other places so the elbows/arms will only rest on the arm support. The arm support should be seen as a resting/relaxing area, not as being a supporting and stabilizing area.

The arm support, half tray and tray should be used to create a platform to rest the arm onto and in this way help to create stability by avoiding that the weight of the arm de-stabilizes the body.

Head support

The head support is sometimes needed to create a constant support and in other cases to provide a support only to rest the head against at certain situations. Tilt and recline will influence the head position and an adjustable head support position is of high importance.

Tilt and recline

Especially for passive users, the tilt and recline functions are important for variation of the seating position. Having said so, they can also be used to create stability.

After having made our choices for the leg support, the seat unit including cushions, head, and arm support, we need to use the tilt and recline to balance the user - to optimize position and stability. Know that increased recline will create an increased forward slide, create larger shar forces, pressure, and tissue deformity, and should be used with care. Always use tilt first before adding recline.

Creating stability through secondary position tools

The challenge we face when adapting a wheelchair to a user is complex, since different users need different support to maintain position and stability.

A SCI (spinal cord injury) user has often challenges related to the level of instability due to the damage being at a certain level of the spine, while e.g. a CVA (cerebrovascular accident or stroke) user often has a strong difference between the function of the left and right side of the body. Some users have a lack of force as being the main challenge for creating position and stability, while others have strong uncontrolled movements as their challenge.

Tray and half tray

It is often forgotten that a tray or a half tray can have a stability function as well as a "tray" function. In some cases, a tray or a half tray will be the perfect support for the arms. It is though important to recall that the placement of the arm will influence the center of gravity so remember always to check the symmetry of the user.

Side support

Side supports are also great to use when creating position and stability. In many cases the optimum position is created but the "**time factor**" is forgotten. Remember, that wheelchair users are often sitting between 8 and 12 hours in their wheelchair. This requires the need to sit and be active at certain times, and to sit and relax at others.

The built-in side supports of the back cushions provide the first quality of support which can be reinforced by simple side supports. If this does not provide sufficient stability, more complex side supports can be used, which can be adjusted in all directions and create stability for users. For users who have a forward tendency this side support can as well support the front of the trunk.

Belts and harnesses

Belts and harnesses are great secondary positioning tools and can help to create stability.

But remember that many factors need to be taken into consideration.

Some considerations are:

- Some belts or harnesses can restrict circulation, blood flow, air flow when not used correctly. E.g., always use a hip belt when the user uses a harness. If no hip belt is used, the user can slide downward and forward and can suffocate.
- Depending on the forces on the belt and on the frequency, it can be important to know about slippage of the belt. When using a belt for a user with involuntary movements, a belt with a lot of slippages may cause loss of position, an increased chance to develop decubitus and, risk of sliding out of the chair
- The angle at what the belt or harness is placed is essential to the function which is needed. A hip belt can easily be placed at 5 different angles within a 90-degree range. The angle of the hip belt needs to be seen in relation to the users' needs for position, mobility, and stability. Choosing the wrong angle can again mean loss of position, an increased chance to develop decubitus and, risk of sliding out of the chair.

Many active wheelchair users do not feel that they need what they call "a safety belt". They see the hip belt as a safety device to prevent that they fall out of the chair. What they do not see is that a hip belt can be a

secondary stabilization tool to maintain good position when they propel the wheelchair and increase the risk for developing pressure injury due to increased pressure-, shear-, and friction- forces which lead to cell deformation and start the negative process.

Also, Power wheelchair users can have great advantage of using belts and or harnesses to create a stabile position where it will be easier to control the controller of the wheelchair.

Variation

Tilt and recline are functions which are used to create variation in the wheelchair. We are all aware of the fact that we need to move more and that we need to vary our position as often as we can to stay healthy. The NHS (National Health Service in UK) recommends standing up every 30 minutes for non-wheelchair users, having a desk job. So how often do wheelchair users change their position? If we look at a summarize of level 5 evidence studies (Evidence from systematic reviews of descriptive and qualitative studies (meta-synthesis)), which was published at "Spinal Cord Injury Research Evidence", we can see that SCI wheelchair users do not change position enough:

Yang et al. (2009)[1] completed an observational study with the intent of describing the sitting behaviors of 20 people (18 men, two women) with spinal cord injury who use a manual wheelchair as their primary means of mobility and live in the community. Data was collected using a data logger and six force sensor resistors on the seat of the participants' own wheelchairs to track sitting contact on the wheelchair seat over a one-week period. The results indicated that on average these participants lifted off the seat surface **once every one-two hours**, **sat for 9.2 hours a day**, and sat for long periods of time without shifting weight (range of 97 minutes to 3.7 hours).

Sonenblum[2] et al. (2016) also found that of the 28 people monitored in their everyday lives, that the weight shift frequency to meet the clinical guideline recommended criteria for pressure management, none of them met the criteria of every 15-60 minutes. Participants sat on **average for 140 minutes** +/- 84 minutes without shifting their weight at all. They also reported great variability in weight shifts across participants and for the same participant across days.

Similar results were found by Sonenblum et al. (2018c) in their study of 29 adults who were 2 years post SCI. Participants were grouped based on pressure injury history. Findings indicated that weight shift movements that had potential to affect pressure management were performed **less than once every 3 hours** for both groups, with the no pressure injury history group completing slightly more pressure management weight shifts that the group with pressure injury history. Weight shifts that did not fully offload and in-seat movements occurred more frequently (1-2.5 and 39.6-46.5 times per hour respectively). Variability was noted as considerable for all movements across participants as well as for the same participant across days.

A conclusion on variation of position and the amount of **tilt and recline** following "Spinal Cord Injury Research Evidence's":

- It cannot be assumed that a change in interface pressure through use of tilt/recline equates to an increase in blood flow at the ischial tuberosities (IT).

[1] https://scireproject.com/evidence/rehabilitation-evidence/wheeled-mobility-and-seating-equipment/pressure-mapp/
[2] https://scireproject.com/evidence/rehabilitation-evidence/wheeled-mobility-and-seating-equipment/pressure-mapp/

- The variability in blood flow and interface pressure changes associated with tilt/recline, supports the need for an individualized approach to education around electrically operated positioning device use for pressure management.
- The type and duration of position changes for pressure management must be individualized.
- More research is needed to determine the parameters of position changes in relation to interface pressure and blood flow at the sitting surface tissues to help prevent pressure ulcers post SCI.
- While electrically operated positioning technology including combinations of tilt, recline and stand, offer many health-related benefits, individualized assessment and thorough consideration of contraindications are required to ensure safe and appropriate use.
- To mobilize knowledge related to pressure, and muscle/skin perfusion into clinical practice further research is needed to determine:
    1. The influence of cushion type on muscle and skin perfusion
    2. The effects of friction and shear on skin and muscle perfusion and pressure during use of recline and/or tilt and/or standing
    3. The influence of postural deformities/tendencies on perfusion levels on both of the above
    4. The effects of duration of large amplitudes of position changes within participants' regular daily routines of position changes.

Variation does not only influence the skin/pressure injury. There are several other parts of the body which also will be influenced by tilt and recline and variation.

The **angle of the recline** should normally not be changed since the recline angle is important to have the correct position for the user. Changing the recline angle will influence the position of the pelvis and increase the incidence of losing position/sliding forward. The **tilt angle** should be used when creating variation and if recline needs to be used, this should be done after the tilt angle has been changed so much that sliding forward is not possible.

Musculoskeletal pain because of wheelchair use is very common amongst wheelchair users, affecting 50% of patients[3]. The study[1] also shows that the most common pain syndrome is **shoulder pain** and other pain syndromes include neck, elbow, wrist, hand, and low back pain. Propelling the wheelchair is clearly the main reason for having shoulder pain. Optimal adjustment of seating position may prevent pain and is important to be taken into consideration.

Having a certain amount of stability and muscle power is of great help when variation is needed. Henderson concluded with that **bending forward** creates better pressure relief compared to tilt.[4] A bending forward technique which can be used by the user will make the user more independent, results in less pressure under the seat bones for a period and does not create a negative load on to the shoulder.

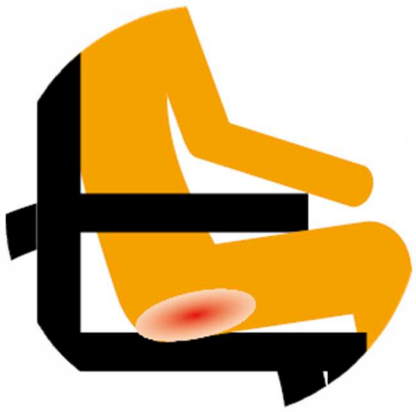
When the user does not have enough force to perform an active change position program, electric tilt and recline functions can be of use.

Although it is not always easy to justify variation in the wheelchair from a research point-of-view looking at each little detail, we believe that variation used to change the load on the muscle- skeletal-, organ-, lymph-, nerve system and skin will contribute to a positive situation for the user.

[3] Liampas, A., Neophytou, P., Sokratous, M. et al. Musculoskeletal Pain Due to Wheelchair Use: A Systematic Review and Meta-Analysis. Pain Ther 10, 973–984 (2021). https://doi.org/10.1007/s40122-021-00294-5

[4] 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;75:535–539.

Skin protection



To understand the mechanism behind skin damage and protection, we need to realize that in wheelchairs, 50% of the body's weight is supported by 8% of the body's surface, as being on the **ischial tuberosities** or **seat bones**.
Normal capillary pressure ranges from 16-33 mmHg and sitting on a regular cushion in a wheelchair gives a pressure under the ischial tuberosities of about 100 mmHg. This means that pressure greater than 33mmHg in combination with prolonged time creates tissue necrosis which is negative for the skin.

Further negative factors have been found in several studies:

- In one study of 25 persons with SCI and eight persons who did not have SCI, it was noted that there was more asymmetry in the SCI seating pressures which increases the pressure on one of the ischial tuberosities even more.[5]
- Several investigators reported that the center of pressure displacement was smaller for patients with SCI than in healthy volunteers in all directions[6].
- A study from 2020 provides quantitative evidence that Biomechanical Risk, or the intrinsic characteristic of an individual's soft tissues to deform in response to extrinsic applied forces, is greater in individuals at greater risk for pressure ulcers[7].

If we look back at the long-term seating challenge as being "**age with quality, despite the disability**", we also need to look at the **aging skin** which even adds an extra challenge to this mechanism. In the elderly, there is a diminished amount of tissue between the skin and bone, which may make the skin more at risk for decreased tolerance of pressure and shearing injury. In very old adults, age-related skin changes induce flattening of the layers at the dermo epidermal junction, loss of tissue elasticity, and thinning of subcutaneous tissue which all increases the risk for pressure injury. [8]

When we add one more factor to this, as being **microclimate**, we will even challenge the system more. Incontinence / moisture, raised temperature, means a higher risk for skin damage.

If we take all these factors into consideration, it is not hard to understand why the following results were found in a cross-sectional study of 218 persons with SCI. Most had pressure injuries (85.7%), whereas 46.3% had multiple surgical procedures for their repair, with 17.5% of pressure injuries that had not healed, mostly on the ischial tuberosities[9].

Another factor which is not talked about so much is one secondary negative side effect of pressure sore, which is **scar tissue**. Scar tissue can take 12 to 18 months to mature but will only ever reach 80% of tensile strength of unwounded skin[10]. This means that the skin will tolerate less, and risk for new pressure sores are higher.

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[5] Guitierrrez EM, Alm C, Hultiling C, Saraste H. Measuring seating pressure area, and asymmetry in persons with spinal cord injury. Eur Spine J. 2004;13(4):374-379
[6] Ragan R, Kernozek TW, Bidar M, Matheson JW. Seat-interface pressure on various thicknesses of foam wheelchair cushions: a finite modeling approach. Arch Phys Med Rehabil. 2002;83(6):872-875. And Karataş G K, Kapukran A, Kanatl, UCenter-of-pressure displacement during postural changes in relation to pressure ulcers in spinal cord-injured patients. Am J Phys Med Rehabil. 2008;87(3):177-182.
[7] Sharon E.SonenblumaDavinSeolaStephen H.SpriglebJohn McKayCathcartc. Seated buttocks anatomy and its impact on biomechanical risk, Journal of Tissue Viability, Volume 29, Issue 2, May 2020, Pages 69-75)
[8] Farage MA, Miller KW, Elsner P, Maibach HI. Characteristics of aging skin. Adv Wound Care. 2013;2(1):5–10
[9] Simiya T, Kawamura K, Tokurhiro A, Takechi H, Ogata H. A survey of wheelchair use by paraplegic individuals in Japan part 2; prevalence of pressure sores. Spinal Cord. 1997;35(9):595-8.
[10] Martin P, Nunan R. Cellular and molecular mechanisms of repair in acute and chronic wound healing. Br J Dermatol. 2015;173(2):370-378

So, what are the most regular contributing factors for skin failure of a wheelchair user?

- Ischemia created by pressure (restricted blood flow)
- Shear- and friction forces
- Microclimate (moist and temperature rise)
- Sensory impairment/altered level of consciousness
- Disease states (e.g. chronic kidney disease)
- Body oedema
- Wrong nutrition (not enough calories and protein)
- Smoking
- Age
- Immobility

As we can understand after having looked at the above factors, it will be the small differences which can make a large difference. Each negative factor will contribute to spiral the skin health of the wheelchair user downward.

In what way can our choice of wheelchair contribute?
We need a wheelchair with optimum possibilities regarding skin protection:

1) Prevent high pressure at bony prominences
2) Reduce shear- and friction forces

These 2 factors are strongly influenced by the position and stability of the user. It has been shown that by using appropriate **support surfaces** like correct seating cushions, backs, side support, correct amount of tilt and recline and all other accessories which are needed to create a good position and stability, we can **reduce the turning /repositioning frequency** required from every two to four or six-hourly[11].

3) Optimize microclimate (reduce temperature and moist)
4) Allow mobility/create variation

[11] Rich et al 2010; Vanderwee et al 2006;Defloor et al 2005

What is the conclusion of “The sum of the total”?

Our slogan is “Inspire joy of life” which can be done by adapting the wheelchair to the user to allow for high quality ADL – activity of daily living and social life and to age well with a disability.

This can be reached by optimizing position, stability, variation, and skin protection. These factors create the basis to reach the quality of life as we experience it and make it possible to be included in a social life, which will again stimulate a healthy mental state.

5 Seating Steps

To help wheelchair professionals in creating good seating solutions, Meyra Group has developed the 5 Seating Steps. This tool guides you through the fitting process and increases the quality of seating and includes the following steps:

1. Clarify expectations and challenges
2. Observe and assess the user’s situation
3. Define seating strategy and set SMART goals
4. Create seating solution
5. Evaluate

Feel free to download it on www.My-Netti.com