# Bodypoint®

## Belts and harnesses articles

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# Welcome to the Bodypoint Article Compendium

At BES Healthcare, our mission is to provide 'Best in Class' solutions that enhance the quality of life for users. We understand that no two individuals are the same, and therefore, their equipment needs vary. Rather than treating assistive devices as mere commodities, we focus on offering tailored solutions that promote postural support and comfort. Our curated range of high-quality products from around the world ensures that individuals receive equipment suited to their unique needs.

## Education and Training

To help healthcare professionals maximise the benefits of our products, BES offers comprehensive education and training sessions. These sessions focus on 24-hour postural management, clinical needs, and assessment techniques, equipping therapists and carers with the knowledge they need to deliver the best possible care.

## Superior Service

Our commitment to superior service is reflected in our team of highly trained Assistive Technology Specialists. Taking a holistic approach, they provide tailored assessments and expert guidance, ensuring that individuals receive the most effective postural support solutions.

## About This Compendium

This collection of articles originates from Dr. Barend ter Haar's monthly 'Let's Get It Clear' column, featured in THIIS and available on the BES Healthcare website's Knowledge Hub. These articles focus on best practices for using Bodypoint postural support devices, offering clinical insights and practical guidance to healthcare professionals.

## Why Bodypoint?

Bodypoint stands out as the brand which pioneered testing to, and meeting the international wheelchair seating standards for postural supports, specifically ISO 16840-3, -10, and -15, ensuring suitability, durability, safety, and performance in postural support.

## Debunking Myths

A common misconception is that belts and harnesses from one manufacturer cannot be used on another manufacturer's wheelchair. Bodypoint belts and harnesses, when used with the appropriate mounting hardware, are fully compliant with ISO standards and can be safely and effectively fitted to any wheelchair. Through this compendium, we aim to provide valuable insights and practical knowledge to help professionals achieve the best outcomes for wheelchair users. To explore more articles and resources, visit www.beshealthcare.net



# Contents

**Let's Get It Clear No. 6**
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**By Dr Barend ter Haar**

# Requirements for belts and harnesses in seating

**What are lap belts for? In wheelchairs, shower chairs, or other seating systems, some are designed for restraint in an accident, some just for safety to protect the occupant from falling out, and some for postural control (known as postural support devices or PSDs). The design and positioning for each of these different functions are different.**

Postural support devices, such as positioning supports, have a specific purpose, which is to support an individual, to help maintain and increase day-to-day functionality for the individual, and to protect against the development of skeletal deformities, or to correct them. These devices, with their postural support purposes, are not to be confused with safety belts and similar devices designed to act as vehicular occupant restraints, nor with simple 'safety' belts.

The records of MHRA (Medicines & Healthcare products Regulatory Agency) show that over the last 15 years there have been four reported deaths and 17 serious injuries in the UK involving, or attributed to, failures relating to pelvic posture supports or anterior trunk postural support devices.

These deaths are thought to have occurred as a result of inappropriate placement, adjustment, or failure of the supports. Users appear to be confused as to best practice, and the reasons why postural supports need to be placed and adjusted according to the occupant's needs.

The MHRA originally provided guidance in the UK on the placement of pelvic positioning supports, but the advice was in effect more appropriate for wheelchair tie down and occupant restraint systems, rather than positioning supports.

This advice was updated in 2015 in MDA/2015/018[1]. This new guidance placed the onus on the manufacturer or equipment prescriber to decide what might be best for an individual, although with minimal guidance on how this was to be ensured. This introduced the risk of a variety of interpretations, which might not be consistent, and which could cause further confusion.
For this reason, a British Standard, BS 8625[2], was produced which specifies requirements for the selection, placement, and fixation of flexible postural support devices within seating devices and systems, including wheelchairs. Seating postural support devices (PSDs) can be involved in one or more situations, including static seating, wheelchair seating, shower chairs, etc.

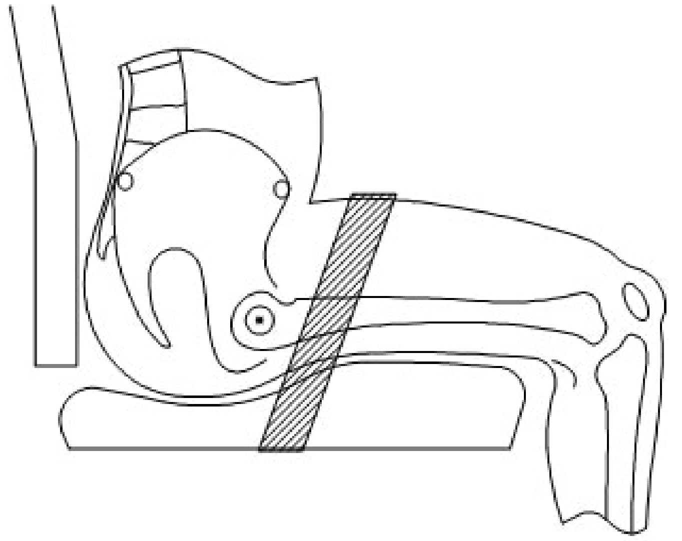

**Figure 1 from BS 8625 showing optimal positioning of a pelvic positioning belt in front of the hip joint to protect against the pelvis sliding forward and thus keeping the pelvis in a neutral upright position.**

The PSDs enable the seated person (the occupant) to be positioned to maximize their functional activities in a safe environment. These requirements have a balance of maintenance of posture and of safety. This British Standard has been created for use by clinicians, engineers, carers, occupants, manufacturers, retailers, and repairers.

BS 8625 gives guidance on the benefits and downsides relating to the appropriate vs inappropriate choice and positioning of belts and harnesses, including topics around: restraint vs positioning, safety, paediatric positioning, materials, and transportation. Specific advice is provided around pelvic positioning, and then trunk, leg, foot, head and wrist support.

There are instructive annexes on:

A. How to measure a person;
B. How to measure a PSD;
C. The difficulty relationship between the operability of PSD and cognitive and/or physical dexterity level of occupant;
D. PSD mounting devices;
E. Prevention of risk of asphyxiation.

Apart from the specified requirements – i.e. the 'shall' specifications (such as: "Seating systems and wheelchairs shall be supplied with space available to mount PSDs in the positions required by this British Standard"; "PSDs shall be tested in accordance with the tests in ISO 16840-3, and have passed the tests"; etc.) – there are commentaries setting the scene for the requirements.

In BS 8625, clinicians now have access to definitive information which was previously missing from the MHRA guidance. Following the requirements within BS 8625 will lead to better outcomes, and improved safety for medical equipment users.

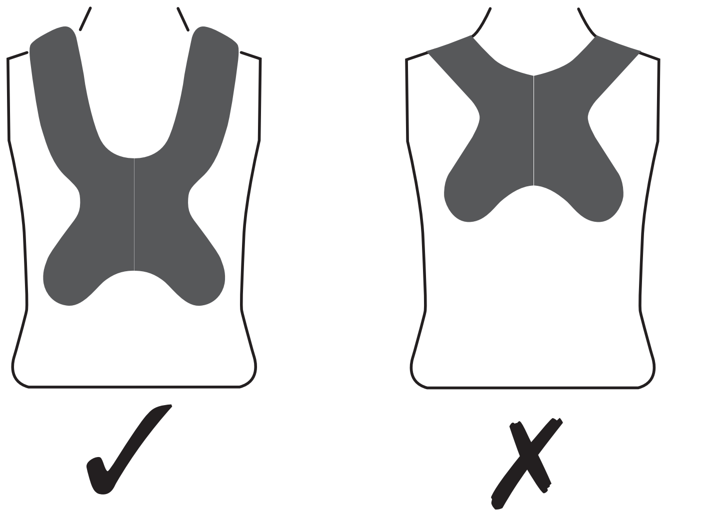

**Figure 15 from BS 8625 showing the new label for use with chest or shoulder harness**

**References**

*1. MEDICINES & HEALTHCARE PRODUCTS REGULATORY AGENCY. MDA/2015/018. All posture or safety belts fitted to supportive seating, wheelchairs, hoists and bathroom equipment. London: MHRA, 2015.*

*2. BS 8625:2019 Selection, placement and fixation of flexible postural support devices in seating London: BSI, 2019.*

**Let's Get It Clear No. 19**
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**By Dr Barend ter Haar**

# What makes a good positioning belt?

## 1. The anatomy of a belt

**The first consideration of a seating system is usually its cushion. This aspect has been covered elsewhere in our downloadable booklet "What makes a good cushion?" Equally important components of many seating systems are the postural support devices (PSDs) provided with the seating to complement the cushion and back support elements. This is the first in a series covering PSDs, where we look at the design of different components of a positioning belt to ensure optimal results for the user.**

Let's start with a reminder that positioning belts are not to be confused with 'safety' belts, as used in vehicles, which are made available as restraints. Positioning belts are intended to help position the individual to assist them in postural control and normal day-to-day functions, whereas vehicular restraints are there to restrain the body from flying out of the seat in a traffic accident. The applications, and therefore the designs, are very different for the two different types of belt, and should not be confused with each other.

Postural support devices (PSDs) are medical devices designed to control body movements, either blocking, minimising, or guiding movements of specific body segments to achieve desired outcomes, while including safety within the seating system. Typical outcomes include increased sitting stability, maintained or corrected posture, increased reach, enhanced propulsion of a mobility device, or maintenance of a desired seated position for safety purposes (including prevention of falls from the chair). In many cases, the purpose of a PSD can be a combination of one or all of these factors.

**Pelvic positioning belts**

Before other PSDs (e.g. ankle or shoulder supports) can be issued, the individual will need a pelvic positioning belt, and we will therefore be concentrating on these in this article. Position and control of the pelvis is critical to postural alignment and control, and there's potentially a lot of movement to control.
The lowest vertebra in the spinal column, L5, is attached to the top of the pelvis. The pelvis has scope to rotate in three dimensions: posteriorly and anteriorly as viewed from the side; obliquely to the left or right when viewed from the front; and rotationally when viewed from above. All these movements get translated into the spine via the L5 vertebra.

Postural reflexes drive people to strive to maintain their centre of gravity within this base of support. Due to the connection of L5 to the top of the pelvis, any change in pelvic position in turn affects the shape of the spinal column. For example, when the pelvis tilts posteriorly, forward flexion tends to occur in the spine leading to a kyphotic posture. When the pelvis rotates obliquely (in the frontal plane), this usually causes lateral flexion of the spine leading to a scoliotic posture.

The positioning of the pelvis is therefore also critical for the alignment of the spine. Some of these 'asymmetries' are unavoidable (or 'fixed'), and from time to time some are desirable. The important element is to control them appropriately, and that is why the selection and placement of flexible PSDs is so important (see BS 8625[1]). The position of the pelvis also greatly changes the distribution of interface pressures between the occupant and any support surfaces, especially the seat cushion and back support. This is an important consideration for the prevention of pressure injuries.

A pelvic positioning belt is employed to bring as much control as possible to the pelvis, to the benefit of many other parts of the body, and for functional activity.

**The anatomy of a flexible positioning belt**

The key components of a flexible positioning belt are the webbing, the padding under the webbing, the buckle (or other closure), and the means to fix the belt to the seating system. Closures and mounting systems are covered in more detail in later articles in this series.

A description of the components of a belt are described in Figure 1.

**Webbing**

The webbing materials need to be strong enough to be able to withstand the forces applied to them by the chair's occupant, adjustable for a good fit, and non-slip so that they stay in place. BS 8625[1] requires that the belts be tested to ISO 16840-3[2], which covers static and repetitive load tests. Amongst the pass/fail criteria is one that specifies that the belt should not slip more than 10 mm under the repetitive load test.

In selecting an appropriate belt, the belt length needs to be long enough to be able to thread through the end fittings at the belt mounting points. The webbing width i.e. flexible PSD width: A in Fig. 1) can come in different sizes: up to 25 mm ±3 mm is Small; 26 mm to 38 mm ±3 mm is Medium; and 39 mm to 50 mm ±3 mm is Large (from BS 86251[1]).

**Pressure distribution**

Pressure distribution or redistribution, e.g. by padding, surface contours, or elastic fabrics, should be provided where the belt interacts with the occupant's body, in order to protect the occupant from harm from the webbing materials (e.g. where it might come in contact with bony prominences or where significant force is applied over soft tissues).

Material selection by the manufacturer is critically important. The pressure distribution elements should be designed to follow the contours of the occupant's body, and to dissipate evenly the forces of the support on the occupant's body.

The design should not allow any curling of the padded support such that the forces would no longer follow the contours of the occupant's body. Where edging is applied to the pad to stop fraying of the pad, the edging material should not provide a risk to the tissue integrity of the occupant – from wrinkling or other deformations, or from localized pressure points.

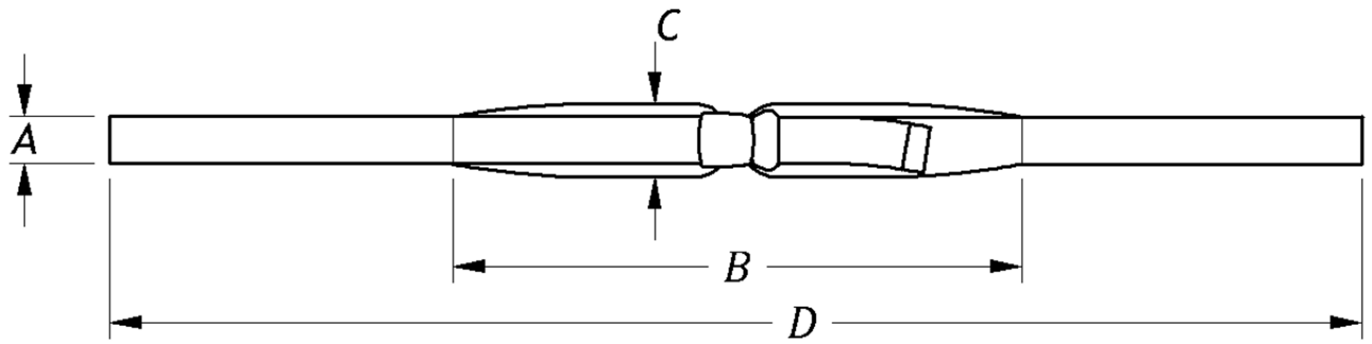


**Figure 1. The components of a pelvic positioning belt**

KEY

A - Flexible PSD width
B - Flexible PSD padded length
C - Flexible PSD pad width

Flexible PSD length: the distance from one end of the webbing to the other when the PSD is laid flat

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# What makes a good positioning belt?

## 2. Adjustment

**The first consideration of a seating system is usually its cushion. This aspect has been covered elsewhere in our downloadable booklet "What makes a good cushion? An equally important component of many seating systems are the postural support devices (PSDs) provided with the seating to complement the cushion and back support elements. This is the second in the series covering PSDs, where we look at ensuring that a positioning belt can be attached and adjusted optimally for the user.**

For a positioning belt or harness to be effective, it needs to be fitted tightly to the individual, whatever clothing the individual is wearing at the time. This means that there is a requirement to provide the means for both fine and gross adjustment to the belt or harness. In modern belts the fine adjustment comes usually from a strap near the buckle attachment, where minor adjustments for different clothing can be accommodated. The gross adjustment comes from when initially fitting the belt or harness by its means of attachment to the chair's framework.

**Fine adjustment**

Pelvic positioning belts can come with either a single or double mechanism for fine adjustment, where a length of belt passes through the buckle, which can then be pulled on for final adjustment. Most buckles provide just a 'single pull' facility, from one side of the buckle, as found in push button and aircraft latch style closures (Figure 1).

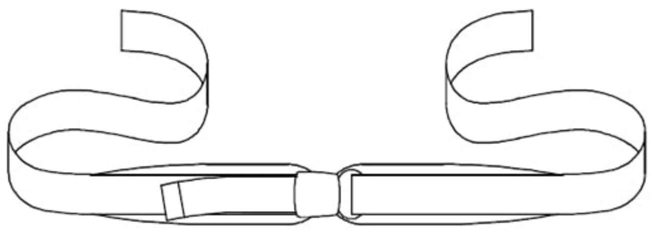

Figure 1 – Centre pull 2-point pelvic positioning support

Some closures, such a side release buckles, allow for a dual pull adjustment, where there is an adjustable extension of the belt on both sides of the buckle (Figure 2). A similar extra degree of double adjustment is available with 'rear-' or 'reverse-pull' set ups, where the adjustability is placed at a distance from the central buckle, with the pieces of adjustment belt placed at the further, or distal, ends of the pad (Figure 3). These double adjustment systems work well for individuals who wish to adjust their belts themselves, as the counter-leverage of the dual systems works more efficiently for them.

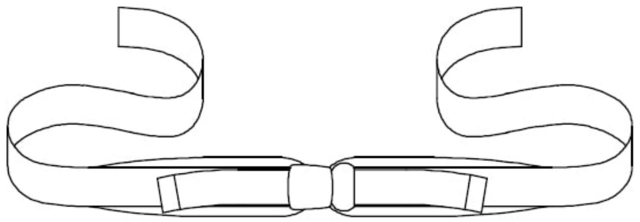

Figure 2 – Dual pull 2-point pelvic positioning support

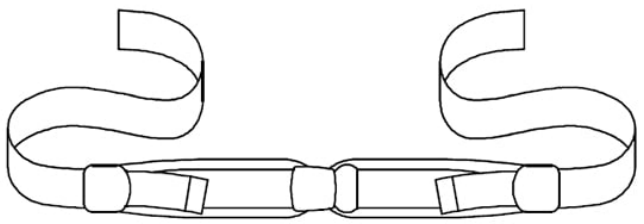

Figure 3 – Rear pull 2-point pelvic positioning support

As a safety element, it is imperative that the belts do not slip and move out of position once they have been adjusted. The standard BS ISO 16840-3[1] allows for a maximum of 5 mm (net 10 mm) slippage for each part of a belt relative to the adjacent part of the belt, under a repetitive load. Not all belts conform to this standard. It is well worth checking that the belts you use do meet this standard for the user's safety!

It is really important to make sure you have adjusted the belt so that it's tight enough. If the belt has been fitted properly in the first place (see below), then when fully tightened up, the pads on each side of the closure should 'kiss' each other. If there's a gap, then further tightening should be carried out if possible.

**Correct belt attachment points**

This element of the fitting process is absolutely critical. Sadly, wheelchair users around the world have died from suffocation due to slipping (submarining) under their positioning belts, sometimes due to the belts having been placed at a 45˚ angle across the pelvis, like a transport safety belt. This was the reason that BS 8625[2] was produced, to give guidance and instruction as to the optimum placement of belts and harnesses to cover a client's positioning needs, and, importantly, reducing the risks of harm to the wheelchair occupant. Sometimes the submarining occurred simply because the belts had not been tightened enough.

**Gross adjustment**

Gross adjustment is usually achieved at the ends of the belt or harness where they fit onto the chair frame. Some means of attachment allow for fast, easy, and fine-tuned adjustments, while others still allow for fine adjustment, but the process can be fiddly and time-consuming. Other methods, such as grommet fixtures mounted in the belt webbing through which the mounting bolt is screwed, do not allow for any webbing length adjustment, and worryingly also may not pass the BS ISO 16840-3[1] tests, as they have been known to rip out of the webbing.

**Triangular end-fitting and three bar slide**

One system that is certainly rather fiddly and time-consuming to adjust is the triangular end-fitting and three-bar slide design. However, this design is still of value as it takes up the least space between the frame and adjacent hardware, such as wheels. A triangular end-fitting provides a means to loop the support webbing through an attachment. The end-fitting usually has a hole through which a bolt can be passed to mount to the framework attachment device. If using a triangular end-fitting, a three-bar slide is needed to fix the support webbing in place once adjusted to the selected belt length. The three-bar slide is in a figure of eight conformation.

The webbing needs to be threaded as per the manufacturer's instructions. For example, the webbing can be threaded through the two slots in a downward direction, passed through the end fitting, passed back through the slots in an upward direction, and then (to avoid the risk of slippage) back through the slots in a downward direction again (see Figure 4).

**Cam buckle end-fitting**

As an alternative to a flat mount and slide, a cam buckle end-fitting can be used to hold and adjust the support webbing (Figure 5). Look out that the cam buckle has been tested, with the webbing to be used, in accordance with BS ISO 16840-3[1] to verify that there is no slippage under the test condition when the clamp is closed.

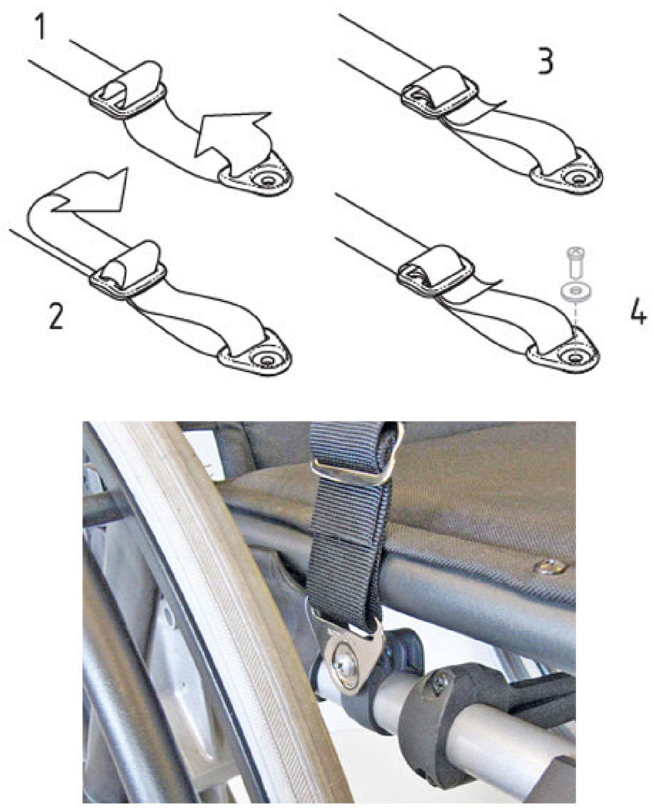


Figure 4. Triangular end-fitting and three bar slide webbing adjustment

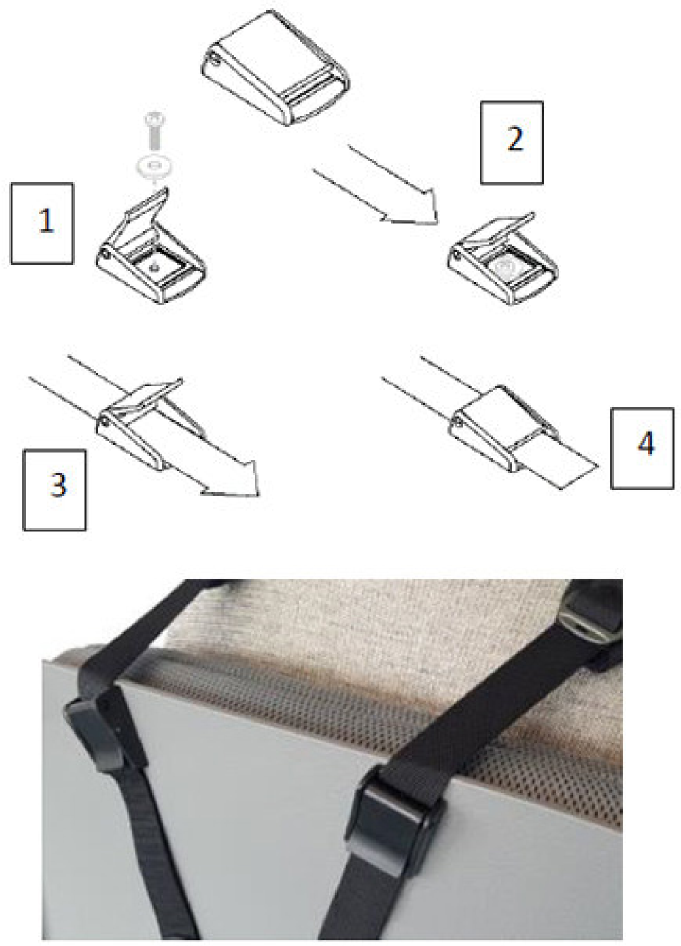


Figure 5 – Cam buckle webbing adjustment

### Locking clamp end-fitting

The ideal set-up is a locking clamp end-fitting which can be used to hold and adjust the support webbing. Preferably, the model chosen will be slim-line enough to fit the space between the chair frame and any other pieces of wheelchair hardware. Because the webbing is passed around a bar to grip itself (see Figure 6), it typically has higher strength and easier adjustment than other types of end-fittings. Again, the clamp should be tested, with the webbing to be used, in accordance with BS ISO 16840-3[1] to verify that there is no slippage when the clamp is closed, under the test condition.

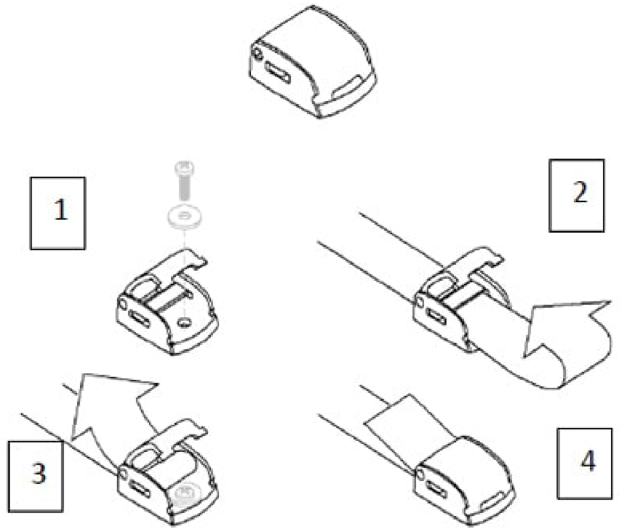


**Figure 6. Locking clamp end-fitting webbing adjustment**

### In conclusion

There's a lot to consider! Having selected the appropriate type of belt for the client, be it centre-pull, dual-pull, or rear-pull, then correct placement on the wheelchair comes next. The means of attachment of the belt to the chair will dictate the ease with which you will be able to make adjustments for the client, both initially, and subsequently as changes in size or clothing come into play. Getting this relatively simple exercise right, and selecting appropriately tested products, is critical for optimum performance, and more importantly, the safety and well-being of the client.

### References

*1. BS ISO 16840-3:2022 Wheelchair seating. Determination of static, impact and repetitive load strengths for postural support devices*

*2. BS 8625:2019 Selection, placement and fixation of flexible postural support devices in seating. Specification (Note: This standard will be available as ISO/TS 16840-15 as well)*





**Let's Get It Clear No. 23**
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**By Dr Barend ter Haar**

# What makes a good positioning belt?

## 3. Closures

**The first consideration of a seating system is usually its cushion. This aspect has been covered elsewhere in our downloadable booklet "What makes a good cushion?" An equally important component of many seating systems are the postural support devices (PSDs) provided with the seating to complement the cushion and back support elements. This is the third in a series covering PSDs, where we look at the design of different closure mechanisms and their pros and cons.**

Postural support devices (PSDs) need to have a closure system (e.g. hook and loop, buckle) that allows the occupant to be secure, and released from the PSD when needed. The system needs to be simple to secure for both fastening and release, but not liable to release accidentally. When tested in accordance with BS ISO 16840-3[1], the PSDs, in combination with the prescribed closure system, are required to meet the pass criteria given therein.

When selecting a belt, the type of closure employed may be the most important element to be selected. The type of closure system chosen should suit the occupant's and/or the carer's ability to open the buckle, bearing in mind any behavioural, mental, or physical impairments.

Furthermore, closure systems need to be selected and located such that they do not create a risk of harm to the occupant by digging into soft tissues (e.g. to the stomach or genitalia) or rubbing against bony prominences. Closure systems should be positioned where they provide no risk of encroaching on moving parts of the wheelchair or seating system.

In the marketplace, there's a number of PSDs which use off-the-shelf buckles which have been designed for use on other items than positioning belts, with different kinds and directions of forces, and as a result they might not have been tested to, and passed the BS ISO 16840-3[1] tests.

In this article, we look at the pros and cons of some of the different styles of closure commonly available.

### Hook and loop closures

The benefits of a hook and loop closure is that it is fast and easy to open up, and also provides for local fine adjustment around different thickness clothing, for example. The downside to this is that this risks the belt not being done up tightly enough. Also, the hook components risk being clogged up with extraneous materials such as fluff from clothing, which can decrease their ability to attach to the loop component.

Where a hook and loop closure system is used, the hook side should be positioned such that it is not in direct contact with the occupant, as it can cause skin irritation. It is also important to note that hook and loop can be made to different grades of peelability, and different grades of slippability. If the peelability is too easy, the closure will not hold in place, whereas if it is too 'sticky', though more secure, it will be more difficult to undo.

In addition, if the grade used allows too much sideways slippability under tension, then it will fail the BS ISO16840-3[1] tests.

### Side release buckles

Side release buckles, of the type often found on back packs, are relatively inexpensive, and thus quite common. They can be released single handedly, and present the least risk of accidental release as compared with other closures.

They have the added benefit that most side release buckles can be used either for single pull belts, or for dual pull belts (see Figure 1), where in the latter they offer twice the available length of webbing for tightening. However, they are not ideal for individuals with poor manual dexterity or strength, who need to release themselves from their PSD, as these buckles require a relatively strong pinch action to release. Where the prescriber wishes to add a security feature to decrease the ability of the occupant from releasing themselves from the belts, this can be achieved by the use of a secondary sliding tab which needs to be manipulated in addition to pinching the side release.

**Figure 1: Belt with side release buckle set up for dual pull operation**

## Push button buckles

There’s a wide choice of push button buckles on the market, some of which will not pass the BS ISO 16840-3[1] tests due to their having been designed for other purposes and markets. For the ‘ordinary’ user, push button buckles are easy to access and operate. However, they are less suitable for some physically impaired occupants who might release themselves accidentally. The amount of force to operate the button varies from model to model, and thus some are easier to open than others. The easiest ones to get out of are those where the tongue release is facilitated by being spring-loaded.

For some occupants, who are more behaviourally or mentally impaired, there is a risk that they might jeopardise their safety by releasing the buckle at an inappropriate time. This has been addressed by some manufacturers who offer slip over ‘security’ covers with smaller holes over the button, which need a pointed device to open the buckle.

Bodypoint in the US has tackled this with a more refined and less bulky solution by providing a choice of three interchangeable button covers with a choice of different diameter holes to access the buttons (Figure 2).

**Figure 2: Interchangeable covers with different diameter holes for a push button buckle to customise the accessibility**

## Latch buckles

Latch buckles are modelled on the buckles found on aircraft seat belts (Figure 3), and are appropriate for occupants with limited manual dexterity, but who can exert a pull on the latch. This can be further assisted by adding a belting strap through the top of the latch cover, which can be easily grabbed hold of. Due to ease of operation, there might be a greater risk of accidental release, though to protect against this, some designs require a greater angle of lift before the buckle is released.

Latch buckles need to be positioned such that they cannot be accidentally released, e.g. by the occupant’s elbow, if the buckle has been placed off centre near the elbow’s natural resting position.

**Figure 3: An aircraft latch buckle, and a similar action, but more streamlined, style of latch buckle**

## Swivel buckles

Swivel buckles allow the two components of a PSD to rotate relative to each other. The two parts are attached by a latching action and have a push release (Figure 4). Swivel buckles are appropriate where a more dynamic relationship between the components of the PSD is required.

**Figure 4: A swivel buckle provides for a more dynamic belt set up**

## Magnetic lock buckles

Magnetic lock buckles have been designed for people who find it difficult to connect a standard buckle as a result of their limited mobility and dexterity, such as those suffering from arthritis or hand tremors, and also those who are partially sighted. The magnets in each part of the buckle help the buckle to align and connect on their own.

A UK manufacturer, Soloc, has also created a design – Soloc Solo – which has been designed for single-handed application and release (Figure 5). The belt comprises of the Soloc magnetic buckle together with a recoiling ‘Presenter Arm’.

The objective of the Presenter Arm is to hold the stud unit in a fixed position for the occupant to present the buckle: once the units are brought together the internal magnets will help align and connect the two units where the stud is mechanically locked in position.



**Figure 5: Single-handed connection, adjustment, and release of the Soloc Solo buckle**

## Belts for easier access

For easier access to the belts, e.g for those with limited manual dexterity, Bodypoint created the Evoflex® belts which have stiffened straps that conveniently pivot out of the way when you want and stay where you put them (Figure 6a). Transfers are easier, and the straps won’t twist or fall into the wheels, avoiding dirt and damage. The Soloc Freedom provides a similar facility, where the two stiffened arms are brought into the vicinity of each other, and the magnetic lock does up the belt (Figure 6b).

## In conclusion

No two clients are the same. The choice of type of belt, and especially its closure, need to be considered carefully to meet the client’s, and maybe also the carers’, needs. Physical, mental, and behavioural abilities or impairments all need to be brought into consideration.

### References


1. *BS ISO 16840-3:2022 Wheelchair seating. Determination of static, impact and repetitive load strengths for postural support devices*

2. *BS 8625:2019 Selection, placement and fixation of flexible postural support devices in seating. Specification (Note: This standard will be available as ISO/TS 16840-15 as well)*


a)

b)

**Figure 6: Evoflex(a) and Soloc Freedom(b) belts offering greater freedom of access to the wheelchair**

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**By Dr Barend ter Haar**

# What makes a good positioning belt?

## 4. Wheelchair attachments

**The first consideration of a seating system is usually its cushion. This aspect has been covered elsewhere in our downloadable booklet "What makes a good cushion?" An equally important component of many seating systems is the array of postural support devices (PSDs) provided with the seating to complement the cushion and back support elements. This is the fourth in the series covering PSDs, where we look at the means to attach positioning belts in the position you require them to be fixed, to provide the desired results, despite the presence of in-the-way 'furniture' on a chair, and without needing to drill into the framework.**

The previous articles in this series covered the anatomy of a pelvic positioning belt; choosing and adjusting a pelvic positioning belt; and the features and benefits of different belt closures. However, to achieve optimal positioning, it is important that the belt is attached to the wheelchair in such a place as the biomechanical forces on the occupant's body are providing the best anatomical positioning of the occupant while providing optimal functional opportunities.

The restrictions that we need to work around are that many wheelchair manufacturers do not supply any predrilled holes in the ideal places; often the chairs have accessories attached to the framework exactly where you wish to attach the belt; the manufacturers do not normally allow you to drill into the framework of the wheelchair without affecting the warranty; and, importantly, a fixed attachment point does not allow for changing positions as the occupant's needs change.

### Correct belt attachment points

Fixing a pelvic positioning belt in the correct position for that occupant is absolutely critical for the safety and optimum functionality of the occupant.

Wheelchairs (as delivered by their manufacturers) may well have a simple belt fitted at the junction between the back support and the seat cushion support structure. This is not guidance as to where the belt should be placed when the occupant is in the chair. Since the manufacturer does not know where the positioning belt is to be positioned correctly for each occupant, this is just an easy place to fix the belt for transport from the factory. The belt itself also may be insufficient for the client's needs (see earlier articles in this series).

Sadly, wheelchair users around the world have died from suffocation due to slipping (submarining) under their positioning belts, sometimes due to these belts having been left at the back support-seat junction giving a 45 degree angle across the pelvis, in the position where you might expect a transport safety belt (restraint). This was the reason that BS 8625[1] was produced, to give guidance and instruction as to the optimum placement of belts and harnesses to cover a client's positioning needs, and, importantly, reducing the risks of harm to the wheelchair occupant.

This article summarises the material in Annex D of BS 8625 which suggests various options to address the challenges of getting the pelvic positioning belt in the right position.

### What to attach to

The first challenge is the variety of tubing and extrusions used by different wheelchair manufacturers, as illustrated in Figure 1. It would appear that most wheelchair manufacturers select the materials for their chair frameworks for structural support of the occupant, for the wheelchair accessories such as wheels and casters, and, presumably, for aesthetics, but too few seem to bear in mind the range of positions and functions required for the different postural support devices which will be mounted on the chair.

A B C D E

Figure 1. Common examples of seating and wheelchair tubing

| Key | | | |
|---|---|---|---|
| A | Round tube (19 mm, 22 mm, 25 mm, 29 mm, 30 mm, 32 mm diameter) | D | Double track taking 6 mm T nuts |
| B | Oval tube | E | Single track taking 6, 8, or 10 mm Y nuts |
| C | Tube with upholstery strip and threaded holes | | |

wheelchair manufacturers select the materials for their chair frameworks for structural support of the occupant, for the positioning wheelchair accessories such as wheels and casters, and, presumably, for aesthetics, but too few seem to bear in mind the range of positions and functions required for the different postural support devices which will be mounted on the chair.

### What to attach with

There are various commercially available accessories that cover the options listed in Annex D of BS 8625, and these are outlined below. There are YouTube videos available (courtesy of Bodypoint Inc) to give guidance as how to mount the Bodypoint versions of these accessories, if you are any way unsure around how to go about it[7]. The relevant link is indicated for each accessory, and is marked video[x], and the link is listed in the reference list at the end of the article.

### Clamps

Most manual wheelchairs have circular tubing (Figure 1 Type A), and the simplest way to get around these is with a circular clamp with a threaded bolt to hold them in place (Figure 2). These are usually designed for 25mm (1") tubing, and have shims for use with 19 or 22 mm tubing. (Video[2]).

Figure 2. Circular clamp

Where there is circular tubing that it is not possible for the clamp to get all the way around the tubing (e.g. there's the seat canvas or an arm support in the way), a frame clamp (Figure 3) or a band clamp (Figure 4) are good options. A frame clamp has an open-jaw: The clamp splits into two parts, and is adjusted by a bolt with a hollow centre to join the two parts. The hollow centre is threaded to take a bolt to fasten the support to the clamp. (Video[3]).


Figure 3. Frame clamp

Figure 4. Band clamp

A band clamp is a flexible stainless spring steel that fits into tight gaps under attachments (e.g. a seat canvas) on a wide variety of frames. The clamp splits into two parts, and is adjusted by a bolt with a hollow centre to join the two parts. The hollow centre is threaded to take a bolt to fasten the support to the clamp. It is suitable for tubing Types A and B in Figure 1. (Video[4]).

### Mounting brackets

A seat tube mounting bracket is a mounting solution for chairs with sling seat upholstery with pre-existing threaded holes (e.g. Type C and D in Figure 1), or a solid seat base (see Figure 5). Elongated holes allow for fine adjustment of the position for attaching the support, and holes are positioned to bolt the wheelchair webbing attachments onto the bracket. The brackets illustrated provide for a snug fit around the sides of a cushion, and can help to keep it in place. (Video[5]).

Figure 5. Seat tube mounting brackets

#### T-slot fastener kits

Many power wheelchairs are supplied with a single or double slotted extrusion at the side of the seat frame, which will accept a T bolt. A T-slot fastener kit provides a means to mount supports directly to slotted seat rails (see Figure 6). They are suitable for use with Type E and F frameworks shown in Figure 1. (Video[6]).

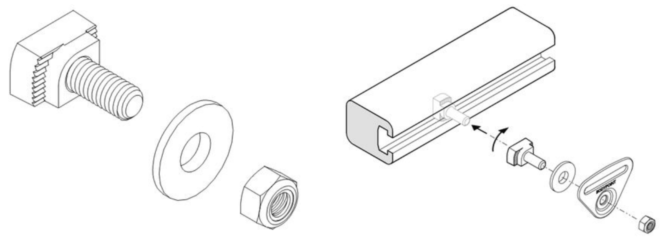


Figure 6. T-slot fastener kit

#### Measuring the frame

As we have seen in Figure 1, wheelchair tubing can come in a wide range of tubing sizes, and you will need to know the diameter of the tubing, or the track widths for the extrusions, to ensure that you have the right mounting hardware.
Bodypoint has created a useful gauge for measuring these variables (Figure 7) if you do not have the wheelchair manufacturer's paperwork at hand.


Figure 7. Hardware gauge

BES Healthcare has a limited number of these gauges to give away, if you would find one useful. Please contact info@beshealthcare.net to request your gauge.

#### References


1. *BS 8625:2019 Selection, placement and fixation of flexible postural support devices in seating. Specification*

2. *Circular clamp www.youtube.com/watch?v=Jlpru7xEpRg*

3. *Frame clamp www.youtube.com/watch?v=_9M_N_lec7k*

4. *Band clamp www.youtube.com/watch?v=TS0Eqqj-QVI*

5. *Seat tube mounting brackets www.youtube.com/watch?v=N2iLDOqaKrI*

6. *T-slot fastener kits www.youtube.com/watch?v=sqavsqP2Rws*

7. *For the full range of Bodypoint videos, go to www.youtube.com/c/BodypointInc/videos*




**Let's Get It Clear No. 29**
**First published in THIIS June 2022**
**By Dr Barend ter Haar**

# What makes a good positioning belt?

## 5. Harnesses and anterior support

**The first consideration of a seating system is usually its cushion. This aspect has been covered elsewhere in our downloadable booklet "What makes a good cushion?" An equally important component of many seating systems is the array of postural support devices (PSDs) provided with the seating to complement the cushion and back support elements. The first four parts of this series concentrates on pelvic positioning belts, whereas this, the fifth in the series, looks at means to position the trunk with flexible anterior PSDs.**

The previous articles in this series covered the anatomy of a pelvic positioning belt; choosing and adjusting a pelvic positioning belt; the features and benefits of different belt closures; and means to fix the belts to the wheelchair frame in appropriate positions. In this article we concentrate on anterior harnesses used to optimise the position of the trunk.

#### What do we mean by a harness?

For this series of articles we have been using the term 'belt' to represent a flexible postural support device (PSD), which has two main points of attachment to take the loads and stresses associated with helping to keep the wheelchair occupant in a required position – these 'belts' are most commonly used for positioning the pelvis.

Admittedly, some pelvic positioning belts have four points of attachment, but two of those straps are for positioning the person, while the other two are for positioning the belt (to stop it from getting out of position).

When we come to positioning the trunk, we often have a wider range of requirements of the flexible PSD. There are some places where a belt, e.g. a chest belt (Figure 1), is appropriate, but more often we are looking for greater surface areas to be covered, and more directions of control. In these cases we often look for a flexible PSD with symmetrically distributed four points of attachment, and refer to these as 'harnesses'.

#### Chest vs shoulder harnesses

The selection of a harness needs to be based upon the ultimate aims for that harness. In some cases, as 'shoulder harnesses' they are there primarily used to provide shoulder retraction. Shoulder retraction assists respiratory and other physiological functions within the trunk, but too severe retraction can restrict the occupant's reach and 'zone of control'.

Many shoulder harnesses can be applied in differing manners both to accommodate the amount of retraction required and for comfort (e.g. to avoid pressure on breast tissue). For example, if the harness is used in 'back pack' conformation (without any of the harness across the chest), this provides the most retraction and least chest involvement. If applied in X style, one has the least retraction, and lesser breast interference.

H style provides a compromise on the degree of shoulder retraction, but has the most breast interference. At least, for most shoulder harnesses, there is a choice. Chest harnesses, on the other hand, while offering some

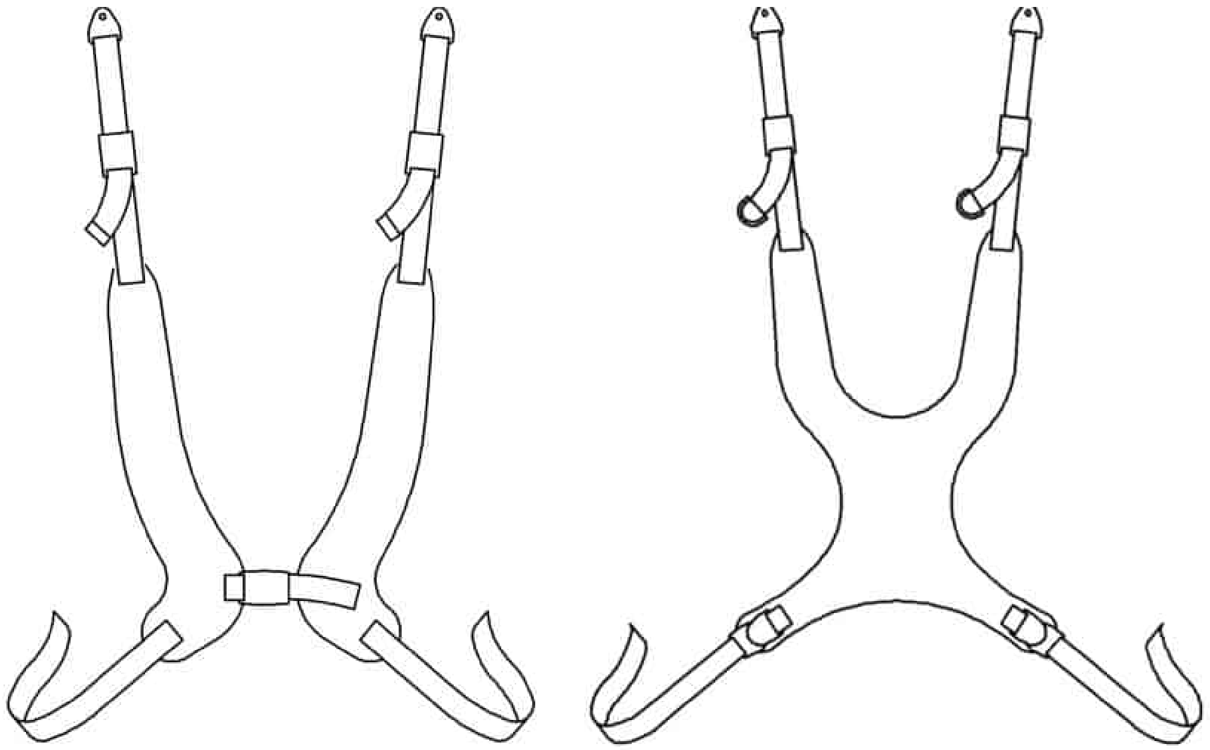


Figure 2. Shoulder harness (left) and chest harness (right)

shoulder control, primarily offer anterior support to the whole trunk, with the load spread over a larger area, but one does not have the choice of application offered by a shoulder harness. There are also specific safety risks involved with chest harnesses (see later).

**Abdominal supports**

Most of the postural supports covered in this series of articles have been designed to minimise impact on soft tissues, and have made use of applying forces across the bonier parts of the anatomy in order to make use of the leverage that can be obtained through these more solid parts to control or adjust the occupant's posture.

There are places where the need to support soft tissues will come into play, but it is important that the forces are evenly distributed over a large area (Figure 3). These include across the abdomen, where an abdominal support comes into play.

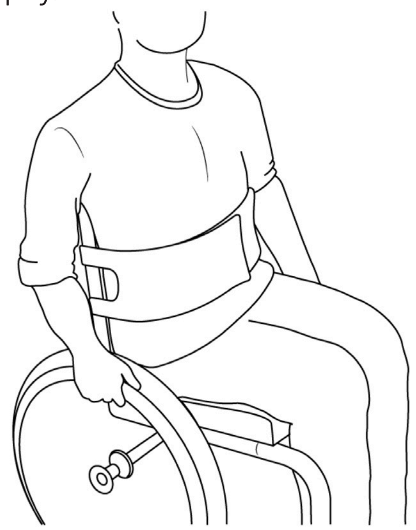


Figure 3. Abdominal support

**The benefits of these supports are:**

*• Support for sagging abdominal muscles*

*• Strengthening abdominal muscles and weakened abdominal walls*

*• Reducing pain while laughing*

*• Avoiding discomfort while coughing*

*• Avoiding squeezing or cramping up of muscles*

*• Assisting toning of abdominal muscles*

**Placement and adjustment of harnesses**

Chest and shoulder harnesses should be positioned so that any central parts are no higher than the lower part of the sternum. The top straps should come across the shoulders horizontally, and if the top of the back support is not in a position to facilitate this, then extra mounting hardware will be required.

If the back support attachment is too high, this can lead to the straps rubbing on the neck, whereas if too low, this will pull the occupant down in the seat into a slouched posture.

The mounting point of the upper straps onto the back support should be close together, thereby reducing the risk of the straps falling off the shoulders (Figure 4).



Figure 4. Placement of upper straps of an anterior trunk support harness

The lower straps should be positioned to maximise the postural control and comfort required for the occupant. Please be aware that if the back support is reclinable, the lower straps will need to be fastened to the lower part of the back support. Some recline in the back support to accommodate the shoulder blades is important – if the occupant is pushed too far forward, they risk being left 'hanging' on the harness.

Most harnesses are offered with front or rear pull adjustment options. The best choice often depends on the occupant's preferences. Some people do not like their carer 'fiddling' around in front of them, so do not like the front pull option. Others do not like people behind them, so do not like the rear pull option. The front pull option gives the occupant the facility to tighten the straps themselves, whereas the rear pull option provides greater leverage for a carer tightening the straps.

**Static vs dynamic?**

The choice of a static rather than a dynamic harness depends on the needs of the occupant. A static harness provides a greater level of positioning and control, especially for those with low muscle tone. A harness with elasticated upper straps allows for a greater degree of movement, and helps the occupant back into position as their muscles fatigue over time during the day.

Elasticated lower straps allow for more freedom of minor adjustments of position, and accommodate the expansions and contractions associated with breathing.

**Safety elements**

The biggest safety concern is around minimising the risks to the occupant of strangulation, and for this reason an anterior trunk harness should never be used without a properly positioned and fastened pelvic positioning belt in place.

Other concerns are around supporting, but not restricting the physiological functions ongoing within the torso, whether this be digestive, respiratory, cardiovascular, and bladder function – and effects on these internal functions being balanced with externally-oriented functional physical needs. We go into more depth around the safety considerations in Part 6 in this series.

**Let's Get It Clear No. 30**
**First published in THIIS July 2022**
**By Dr Barend ter Haar**

# What makes a good positioning belt?

## 6. Safety first

**In this series we have covered various aspects of 'What makes a good positioning belt?'. The previous articles covered the anatomy of a pelvic positioning belt; choosing and adjusting a pelvic positioning belt; the features and benefits of different belt closures; means to fix the belts to the wheelchair frame in appropriate positions; and selection of anterior harnesses to optimise the position of the trunk.**

Positioning belts and harnesses are provided primarily, as the name suggests, for the purpose of positioning. They are not 'safety belts' in the way that vehicular occupant restraints are also named, in that those devices are to protect the person from being thrown forward in a car accident.

However, it is important that the occupant of a seating system is safe. The safety elements include avoiding failure of the postural support device (PSD), avoiding slippage of the PSD, avoiding skin tissue damage arising from pressures from the PSD when tightened, avoiding strangulation, and avoiding falling out of the seat.

There have been recorded injuries and deaths resulting from inappropriately placed or adjusted positioning belts and harnesses, leading to both falls and strangulation. It was for this reason that BS 8625 was published in the UK in 2019, and now adopted internationally in ISO/TS 16840-15 to cover the 'Selection, placement, and fixation of flexible postural support devices in seating'. In these standards, guidance is given for safe practice, and requirements that secondary supports are tested to BS ISO 16840-3[1] and ISO 16840-10[2].

### Pelvic positioning

Some of the deaths have occurred as a result of occupants 'submarining' under their pelvic positioning belts. To avoid the risk of 'submarining', it is critical that the belts are not fitted at the junction between the back support and the seat structure – this 45 degree angle is appropriate for a vehicular occupant restraint belt, but not for a positioning belt.

For those clients at risk of going into posterior pelvic tilt and, as a result, of sliding forward in their seat, the standards cited above require that the belt is positioned anterior to the greater trochanters (Figure 1).

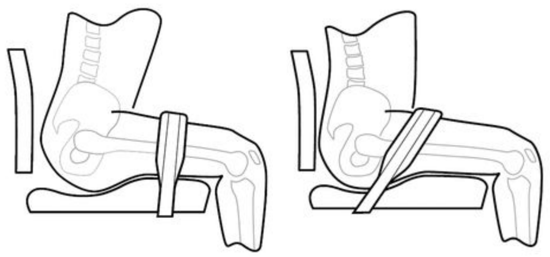


**Figure 1: Options for correct positioning of a pelvic positioning belt (ISO/TS 16840-15)**

The shorter length of belt material involved in positioning the pelvis means that the pelvis would not be able to slip under the belt (as long as it is tightened appropriately). In addition, this positioning in front of the greater trochanters means the occupant is able to reach much further forward, and there's less pull down on the pelvis, and thus decreasing pressures on the ischial tuberosities.

Interestingly, in a paper presented at the 2022 European Seating Symposium meeting, Van der Heyden and Siefert showed that the shear forces through the skin tissues are very high when the belt is at 45 degrees, whereas at the preferred position they are minimal. Greater skin health all round and a much safer positioning solution!



### Sources of strangulation (see Annex E of BS 8625[3] and ISO/TS 16840-15)

Strangulation can arise from the use of postural supports for one of the following reasons:

1. The support is too high and it occludes the airway. This could be because:

- *the support has been fitted too high; or*
- *the support has been adjusted since fitting to sit too high; or*
- *the support has moved out of position since being fitted.*

2. The occupant collapses down in the seat and the airway is occluded by the support. This could be because:

*there is insufficient lateral trunk support such that the occupant collapses to one side; or*

- *there is insufficient posterior pelvic or lumbar-thoracic support to maintain an upright posture, such that the occupant collapses down into kyphosis.*

3. The occupant slides down in the seat and the airway is occluded by the support. This could be because the postural support is:

- *fitted too loosely;*
- *poorly positioned; or*
- *malfunctioning.*

4. Mechanical compression is otherwise applied to the neck, ribcage, and/or diaphragm, due to:

- *the anterior support strap/pad being fitted too tightly;*
- *the occupant sliding underneath the postural support until stopped by their arms and ribcage, placing pressure on the ribcage; or*
- *the occupant submarining totally underneath a postural support until they are stopped by the support being caught around their neck.*

### Protection against strangulation

Use of an anterior trunk support comes with an increased risk of injury or death due to asphyxiation – this is greater when a chest support is used, as compared with a shoulder harness, due to the neck shape integral to the design of the support.

Any anterior trunk support should be supportive, but not restrict the physiological functions ongoing within the torso, whether this be digestive, respiratory, cardiovascular, or bladder function – and protecting all these internal functional requirements needs to be balanced with facilitating external physical functional needs. Furthermore, the risk is increased where the occupant is unable to recognise that something is incorrect about their seating, or cannot verbally express their distress.

- The first aspect of importance is that an anterior trunk support should never be used without a correctly fitted and adjusted pelvic positioning belt, to control the risk of 'submarining' under the pelvic belt (see Part 2 in this series, and BS 8625[3] for further guidance).
- The next aspect is that the central part of the support should be positioned no higher than the lower part of the sternum. ISO/TS 16840-15 provides the graphics (see Figure 2) for a label to be placed, if possible on the PSD, as well as in the IFU.
- The materials from which a chest harness is made is important. In consideration above of the dynamic elements built into a harness, the elasticity needs to be in the straps, and not in the central pad. Chest harnesses that are completely elastic, including across the central pad (sometimes referred to as butterfly harnesses), have a tendency to ride up and there have been reports of occupants being strangled as a result.

Flexible PSDs should never be used as vehicular occupant restraints. They are by definition designed for postural positioning purposes, and their placement on a wheelchair, and their strength, for these purposes are very different from what is required from a vehicle's safety belt.

### In conclusion

A correctly fitted and fastened positioning belt or harness will enhance the occupant's postural support, improving functionality and aiding good health. When done incorrectly, this can lead to harm or death. Do no harm, and follow the guidance and specifications in the standards.

### References

*1. BS ISO 16840-3:2022 Wheelchair seating – Part 3: Determination of static, impact and repetitive load strengths for postural support devices*

*2. ISO 16840-10:2021 Wheelchair seating – Part 10: Resistance to ignition of postural support devices – Requirements and test method*

*3. BS 8625:2019 Selection, placement and fixation of flexible postural support devices in seating. Specification (Note: This standard is available as ISO/TS 16840-15 as well)*

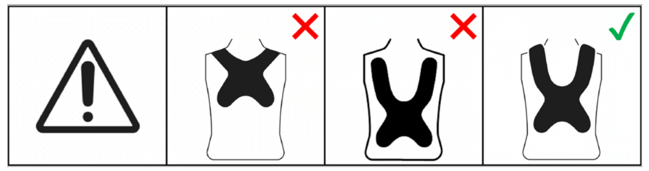


**Figure 2. Suggestion for a label to indicate the correct positioning of an anterior harness**

**Let's Get It Clear No. 47**
**First published in THIIS December 2023**
**By Dr Barend ter Haar**

# Alternatives for getting the pelvis under control

**When seated, we rely on the position and stability of our pelvis to allow us to manage the position and functionality of the rest of our body, in particular the upper body. Seating is an activity, and therefore ideally we need to find means for controlling the pelvis which allow for dynamic activity. In this article we review different approaches that are taken to achieve this control, and the pros and cons of the different methods.**

If we consider controlling the pelvis being akin to controlling a basketball, we have something that can move potentially in three dimensions. We can rock backwards and forwards in one plane, we can rock from side to side in a second plane, and we can rotate around the vertical axis in a third plane. Some of these movements are functionally useful and should be encouraged in order to provide beneficial aspects of seating as an activity, whereas others are counterproductive for functional control of other parts of the body. So how can we facilitate the good moves, and restrict the unwanted ones?

### Making use of bony levers

Most of the places where we apply forces to control the position of a part of the body are linked to the bony bits. Alongside this, in most cases to have full control we require 'three points of control'. If we continue with the ball analogy – if we have a block in a 'V' from behind controlling the left and right, the ball can still roll forward. If we have a block at front and back, it can still roll sideways. In each case we would need a third point of control.

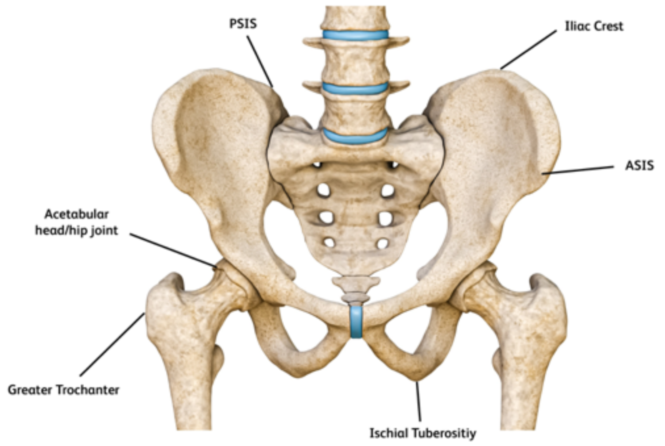
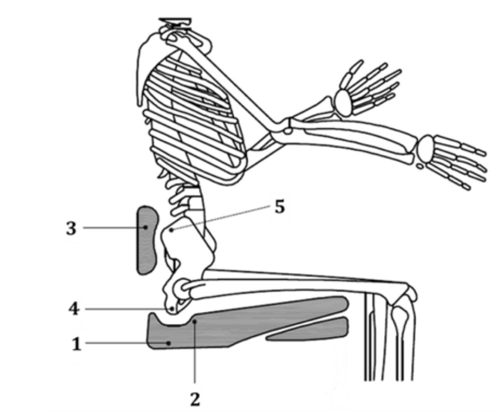



**Figure 1. Useful bony leverage points around the pelvis**

### Controlling posterior/anterior rotation

So what can we do with the pelvis? Although our pelvis may be surrounded by soft tissues, we can get to many of the bony parts quite easily. The key bony points are at the top of the pelvis where we have, at the front, the anterior superior iliac spines (ASISs); at the back, the posterior superior iliac spines (PSISs); and at the side, the iliac crests. On the lower part of the pelvis we have our ischial tuberosities (ITs). In addition, midway up the side, we have the hip joints where our thigh bones (femurs) link in with the pelvis, and it is the femurs that are used to provide the most leverage to the forward movement of the pelvis (Figure 1).

For most of us we require forward rotation of the pelvis to allow optimal forward reach, and therefore we should not restrict this if possible. We go into 'posterior tilt' of our pelvis when we wish to relax, but too much of this means that we compensate by bending our spines forward – doing this for too long at a time leads to the risk of our developing a permanent kyphotic curvature of the spine with the compensatory need to hyperextend our necks so that we can still see forward. As the top and back of the pelvis slips back, the ITs start to slip forward underneath us, exacerbating the problem. The best way to manage this is to have something (like the base of the back support) stopping the pelvis rotating backwards – apply this to the PSISs and not the lower lumbar region – and a thin (5-10 mm) pre-ischial ridge in the cushion just in front of the ITs, to stop them sliding forward (Figure 2).




Key

| | | | |
|---|---|---|---|
| 1 | Horizontal seat base under ischial tuberosities | 3 | PSIS block |
| 2 | Pre-ischial ridge | 4 | Ischial tuberosity |
| | | 5 | PSIS |

**Figure 2. Positioning primary postural supports for positioning the pelvis (ISO/TS 16840-15[1])**

For managing anterior rotation, for example in boys with Duchenne's Muscular Dystrophy (DMD), where the indication is to pull back the front of the pelvis, a 4-point pelvic positioning belt is called for: the padded section of the belt (sometimes with added ASIS pads) is applied to the ASISs, and the webbing fastened to the back posts of the chair. The secondary webbing should be fastened to the seat rails to help prevent the primary belt riding up into the soft tissues of the belly (Figure 3).

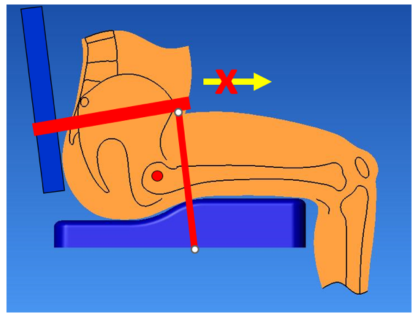


**Figure 3. Positioning of 4-point belt to manage pelvic anterior tilt**

### Using the femurs

For more refined management of the position of the pelvis we make use of the anchoring effect that the femurs have through their attachment at the acetabular (hip) joint (Figure 1). Note, however, that this is only appropriate with a well-formed acetabular joint, since we do not wish to have a risk of subluxation/dislocation of the joint. The forces on the joint from the regular use of standing, especially for growing children, is essential for the proper formation of this joint.

The most common tool used is a pelvic positioning belt. The placement of this belt is important both for patient safety and for optimal functionality. Frequently these positioning belts are erroneously placed in a 45° restraint position at the junction between the back support and the seat frame[1]. This can cause significant safety issues by allowing the person to 'submarine' or slip under the belt, and also pulls the person down onto their ITs. On the functional front, this severely restricts the person's ability to reach forward. By placing the belt in front of the greater trochanters (i.e. in front of the hip joint), the positioning forces are transmitted through the femur – See Figure 4.

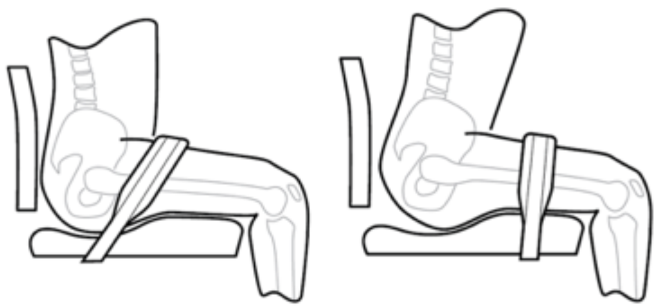


**Figure 4. Options for correct positioning of a pelvic positioning belt (ISO/TS 16840-15[1])**

Some people have used pommels as a means to stop the chair occupant from sliding forwards. The crotch, comprising soft and sensitive tissue, is completely unsuitable for load bearing, and the pommel pad should only be used to assist in abducting the femurs. Likewise, knee blocks have also been used as a means to control the pelvis. The downsides of this are that these blocks can lead to excessive forces on the hip joint, they restrict lateral/medial leg movement, and they place a further visual barrier between the chair occupant and the outside world.

### Leg harness

An alternative to a pelvic positioning belt, and a solution which gives a much wider choice of applications, is one or a pair of leg harnesses (Figure 5).

**Figure 5. A pair of leg harnesses in position**

A leg harness wraps around one thigh, and attaches to the seat rail at its either end. The advantage of managing either side of the body separately is that this allows for the independent control of pelvic rotation and pelvic obliquities at the same time as controlling pelvic posterior tilt. At the same time there is the option of management of the degree of thigh adduction or abduction by selective placement of the harness attachment points. Contraindications are if the person has a weak hip joint, and clearly a leg harness is only usable if the individual is wearing relevant clothing such as jeans.

1. *ISO/TS 16840-15:2024 Wheelchair Seating – Part 15: Selection, placement, and fixation of flexible postural support devices in seating*

**Let's Get It Clear No. 10**
**First published in THIIS October 2020**
**By Dr Barend ter Haar**

# Asymmetry - The good, the bad and the ugly

**The textbooks like to show us as sitting in symmetrical positions, but in reality, we are all asymmetrical and we spend most of our time sitting asymmetrically. This article reflects on the benefits vs challenges of asymmetry and how we might manage the asymmetries in setting up a wheelchair seating system. We touch on belt and harness, lateral support pad, back support, headrest, and even joystick, positioning.**

None of us is symmetrical – our left side is different from the right. Our heart is usually left of centre. Men are asked by tailors "do you dress to the left, sir?" Most of us have one foot larger than the other. We usually part our hair to one side. And so on.

Asymmetry is a fact of life, so why do we set up wheelchairs with the postural support devices in symmetrical positions for dealing with asymmetrical challenges? Probably because that is how the chairs are delivered from the factory.

The key thing here is to break the mindset that a belt, harness, or other postural support device, has to be mounted symmetrically. This article considers what the desired outcomes are and challenges conventional symmetrical positioning in achieving some of those outcomes.

**Lower body**

Starting at the pelvis, almost all pelvic positioning belts are mounted symmetrically i.e. the mounting points on the seat rails are each the same distance from the back of the chair to create a straight line across the occupant's lap. Whilst this might be fine for many users, there are scenarios where it isn't. For example, a client with a pelvic 'windswept' asymmetry in their posture might find that mounting the belt with offset mounting points can actually help correct or accommodate the asymmetry better.

Starting with the guidance to be found in BS 8625[1] that indicates when managing a tendency towards a posterior tilt, the belt should be mounted onto the seat rail anterior to the greater trochanters. This means that either side of the belt can still be mounted any required distance along the seat rail, anterior to the position of the greater trochanter on that side. A belt with a swivel buckle could be the best choice here to help with handling the forces around the buckle from the asymmetry, or the use of leg harnesses where there is a different strap attached to either leg (Figure 1), bespoke to the needs of that side of the pelvis.

**Figure 1. A pair of leg harnesses can be used to manage rotational asymmetry at the pelvis**

Another asymmetrical challenge for clients with 'rotation' of the pelvis is that this frequently presents in combination with a pelvic obliquity, with the upper 'forward' part of the pelvis in anterior pelvic tilt and the lower 'posterior' side in posterior tilt. BS 8625 would suggest the former be addressed with a 4-point belt and the latter with a 2-point belt. The answer is to remove one narrow strap from your 4-point belt, to convert it into a 3-point belt: on the forward raised side of the pelvis, have the wider part of the belt pulling back against the ASIS on that side and fix that part of the belt to the back support uprights.

Have the narrower strap at right angles to come down in front of that side's greater trochanter to stop the wider strap from riding up. On the side with the removed narrow strap, attach the remaining strap to the seat rail in front of that side's greater trochanter. Voilà! We have an asymmetrical posture managed by an asymmetric belt set up (Figure 2).



**Figure 2. Use of a '3-point' belt to manage rotation with obliquity at the pelvis**

Some clients, e.g. affected by a stroke, who wish to propel their wheelchair with their feet can only use one leg. For this asymmetry, the cushion may need to be set up to allow the active foot to be able to reach the floor, while the other leg needs to be fully supported along the thigh while that side's foot is placed on a single foot support. A simple route to achieving this is to place a simple firm foam wedge (that is half the width of the cushion) under the part of the cushion on the side supporting the non-propelling leg (Figure 3).

**Figure 3. Set up of a cushion (without cover) to allow one leg to be lower for single foot propelling of a wheelchair**

**Upper body**

Moving up the body, in the article 'Trunk call: Aligning the upper body', I cover the importance of the positioning of lateral trunk supports for managing a scoliotic spine. Where the scoliosis occurs around the thoracic vertebrae, this can be managed by using the rib attached to the peak of the scoliotic curve as a lever to push the relevant vertebra. Please do take care that the support pad is not only pushing on the correct rib, but also that the pad is rotated so that it pushes along the rib towards the vertebra (and is not a vertical pad which would displace the rib even further) (Figure 4).

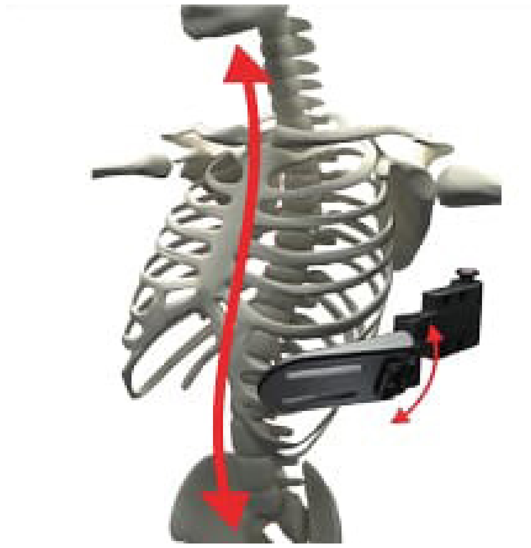


**Figure 4. Rotation of lateral support needed to apply force along the rib towards the apex of the curvature**

The pads on the other side of the torso will be placed at different heights to the active side: active lateral trunk supports being used to handle a scoliotic spine will be asymmetric.

While managing a scoliotic spine, also consider where the back support shell is placed: if the spine is 'off centre' from the pelvis, select a back support where the shell can be positioned off centre (and maybe even rotated to a degree) to accommodate the shape of the spine. Moving up to the top of the torso, where there is rotation around the shoulder girdle, rather than using a full shoulder harness, a single anterior strap to retract the shoulder on the forward rotated side may be all that is needed to help straighten up the torso (Figure 5).

To accommodate asymmetry at the head, use a head support mounting system that allows off-centre positioning around the back of the occiput (for such a mounting system, see Figure 6). Use of a swing-away

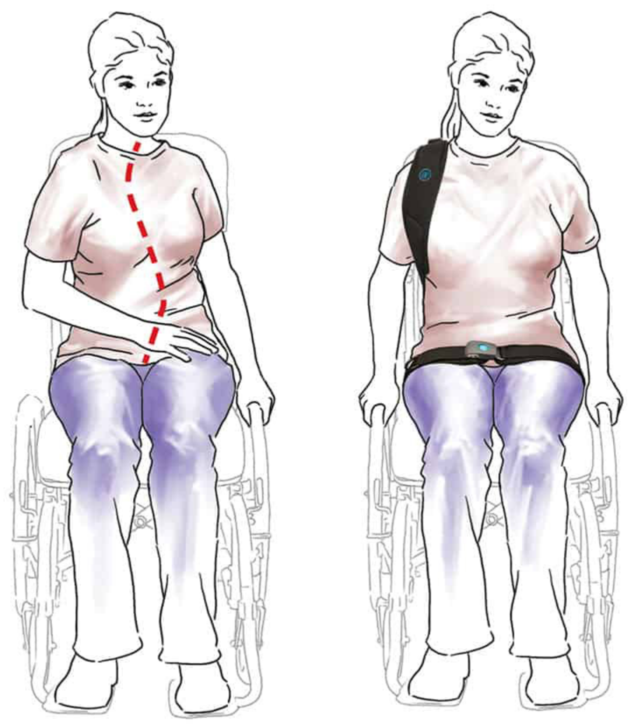


Figure 5. Retraction of one shoulder to counteract rotation at the shoulder girdle

facial pad mounted to one side of the head rest can also help to position the head, but use your hands first (as with any pads) to find if the client has a tendency to move into a support or a tendency to move away from it (thereby using the client's reflexes to guide you where to place the pads to achieve your mutual seating aims).

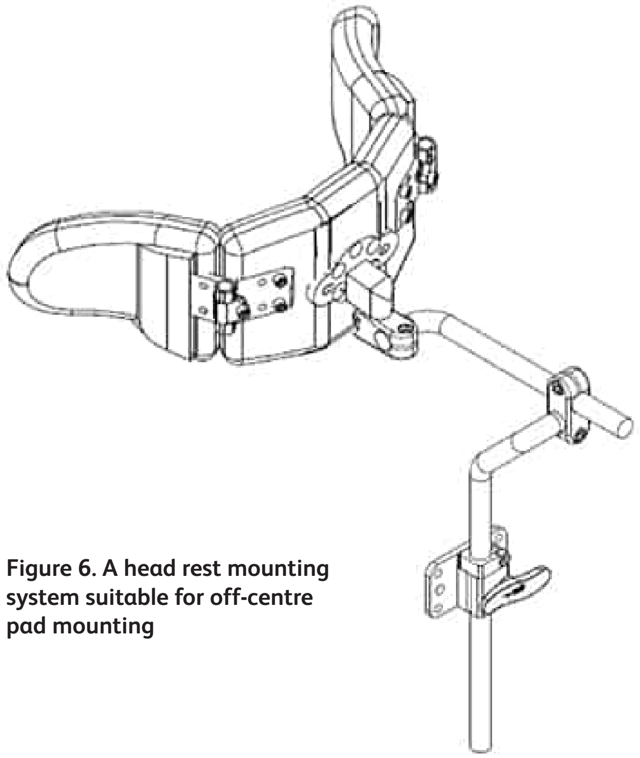


Figure 6. A head rest mounting system suitable for off-centre pad mounting

**The Good, the Bad, and the Ugly**

Often a seating system is trying to work with an asymmetry that has arisen from the effects of gravity on the body, taking a small distortion and making it worse – the bad and the ugly. The clinician's responsibility is to try to stop this happening in the first place, hence the obsession with symmetrical seating. (But, why do we still leave powerchair joysticks at the end of the arm support, encouraging the client to end up leaning to that side, rather than using a swing away arm to allow a midline position when driving?)

Once an asymmetry has developed, then the assessment should consider whether anything can be first done to stop matters getting worse and then, second, seeing if the effects of time, habit and/ or gravity can be reversed. It may have taken some years to reach where we are today and so it may also take some years to get back to where you want to be – or indeed it may never be possible so can only be accommodated.

However, there are places where asymmetry may be a good thing. Asymmetry often restricts our degrees of movement – the bad. But when we want to restrict movement, for example with a tendency towards not easily controllable athetoid movements, restricted movement is desirable – the good. For these clients, creating asymmetries, such as crossing legs or hooking an arm around the back support uprights, can allow enough finer motor control elsewhere to be able to handle a joystick, for example. The seating system should allow this.

Finally, look at your position as you read this article. How symmetrically seated are you and how different is your position from ten minutes ago?

We spend a lot of time moving from one asymmetric posture to another for comfort, for communication, for functionality, for skin tissue health, and so on. Are the wheelchairs we supply to our clients allowing them to move around as we do, while managing the good vs the bad of asymmetry?

**References**


1. *BS 8625:2019 Selection, placement and fixation of flexible postural support devices in seating London: BSI, 2019.*





**Let's Get It Clear No. 64**
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**By Dr Barend ter Haar**


# What makes a good trunk support?

## 1. General principles

**Our upper body, based around our trunk, is the most important part of our body when it comes to our overall health, and therefore also our seating considerations. It is also essential to consider sitting, in the same way as walking or standing, to be an activity. So how can we support this functionality?**

While taking into account our interactions with the outside world, we also need at the same time to take into consideration that our trunk houses the vital organs responsible for many of our most important physiological functions: breathing, blood circulation, digestion, excretions, and reproduction, to name but a few. So all this activity is going on on the inside, while the trunk is providing the stable base to permit the distal activities provided by our legs, arms, and head. The core for all this is the somewhat mobile and flexible, but ideally fairly straight, spinal column, which in turn is resisting the forces of gravity working to change its shape.

**A holistic approach**

In a normal healthy body without any impairments all is well within and around the trunk, but what should we do when there is a problem? Traditionally, at least in wheelchair seating, we often fragment our approach, and maybe start with seeing if only a bit of back support will do. But are we clear in what we want to achieve? Do we want only to control or improve the immediate medical conditions, and prevent further physical 'harm' occurring? This 'medical' model often stops there, and ignores the 'social' model of what else we could do to provide additional interventions for improved functionality and activities of daily living.

Let us consider a different angle by looking at the whole upper body, and not just one part at a time. An example might be where an orthotist is asked to provide an orthosis, maybe to compensate for upper body muscle weakness: the result of their involvement, the end product, might be an orthopaedic brace, which can embrace the whole torso (Figure 1).

What we gain from the design of this type of orthosis is that it treats the torso as a whole, and that all the elements are shaped to conform to the individual. In future articles

Figure 1. An orthotic body brace

we will look at examples of where products that conform well to the body's shape can provide better outcomes for the individual.

Taking this further, should we avoid compartmentalising products into posterior vs lateral vs anterior vs superior supports? Most of the appropriate devices that we prescribe will have aspects of a combination of at least two of these 'touch points'. Most back supports will have some degree of lateral support, for example. Likewise an upper body intervention should not be considered on its own without looking at the effects on other parts of the body. If we then adopt the person-centred approach to, say, the selection of a wheelchair accessory (such as a back support) does it not make sense to size it to the person and not to the wheelchair?

Figure 2. The Tarta Original back support

It was the invention of an orthotist who designed the 'Tarta Original' back support (Figure 2), where I first met the design and sizing of an after-market back support being created around the shape and dimensions of the occupant. In the Tarta, its sizing was designated to be comparable with the person's clothing sizing, e.g. Small, Medium, Large (not quite as clear-cut when it was found that one country's small was very different to another's!), and not the width of the wheelchair onto which the back support was going to be mounted. In later articles we will look at what current and future ISO standards recommend as to how we make use of the individual's measures to prescribe items that will fit the person appropriately.

**Support, not rest**

Generally in the seating world we do not consider the more simple items that we might apply to a seating system to be an orthosis as such, even though the definition of an orthosis is "an external medical device for supporting, immobilising, or treating muscles, joints, or skeletal parts which are weak, ineffective, deformed, or injured". In truth, this definition encompasses most of the accessories we commonly apply to a seating system: if we bear in mind that any seating assistive product that we prescribe has these functional aspects, then the occupant will benefit. As a basis, at least we will use the term 'support' rather than 'rest', as in 'back support' rather than 'back rest', for example, to reflect the active functional aspects of the device.

**Movement and functionality**

Being able to move is important for our overall health, through our being able to exercise our muscles and, also, for the health of most of the physiological function encompassed within our torsos. We should never be constricting movement to the degree that it inhibits optimal respiration, for example. Regular muscle activity is also vital for maintenance of bone strength. For the mobility impaired, standing for at least an hour a day provides marked improvement in most physiological functions across the body.

Where an orthosis may be immobilising some parts of the body, we need still to be able to move other parts of our body, to reach items and hence enable optimal functionality around normal day-to-day activities. We need some degree of freedom of movement and postural variation. Postural variation can be a change in posture induced by wheelchair users themselves (we can call this active postural variation) – for example if the occupant's postural muscles fatigue or there is a change in tone, the seating system can adjust to that new alignment and facilitate an optimal posture. Passive postural variation would be where a caregiver changes the occupant's posture depending on his/her postural needs, fatigue, activities, and function.

The elements in a seating system allowing postural variation, in some cases permit free movement, while in other cases they also provide assistance to recover an original position. When an occupant changes posture due to fatigue or tone, a 'dynamic' support is often important, in that a static support will limit movement, and the outcome will most likely be an undesired movement elsewhere, such as sliding (and the occupant is unable to reposition him/herself), or excessive movement of other body segments. Where movement is being facilitated, it is important that the accessory design mirrors the anatomical pivot points of the body – good examples can be found in products like the EPiC seating system from Stealth (Figure 3.), the Hip Grip (regrettably no longer available), the Dynamic Arm Support from Bodypoint, etc.

**Figure 3. The EPiC seating system**

In future articles we will look at the pros and cons of these different flexible vs static alternatives.

**Conclusion**

A good trunk support needs to accommodate the internal needs of the torso, as well as answering the external needs of the occupant. We need to take a holistic and multisegmented approach and consider all three dimensions of a potential support solution. How a support system interacts with the body of the occupant is important at the static surface-to-surface support level, as much as with the facilitation of postural variation. Because of the flexibility of the spine, there is always the risk of spinal distortions developing: devices should be prescribed that facilitate the occupant's needs while maximising safety and protecting against adverse side-effects. Deeper consideration of these aspects will be covered in future articles.



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**By Dr Barend ter Haar**

# What makes a good trunk support?

## 2. Dynamism

**How we position, move, and support our upper body is critical for good health and optimal functionality. But what is involved in positioning and movement?**

**The adjective 'dynamic' is applied widely across wheelchair and seating components, but how does this term apply to the occupant of a wheelchair?**

From the occupant's point of view, the dynamic element of a seating element, or postural support device, facilitates the occupant's ability to carry out everyday activities from their chair. Sitting is an activity, and postures will change during the day to accommodate for fatigue, functional activities, changes in tone, etc. Functional movements during wheelchair use, such as head and upper extremity movements, are most effectively executed when multiple proximal and distal body segments are involved: so we need to be able to vary our posture to achieve our required outcomes. To this end, we might wish our seating system to allow movement within defined locations and zones of control. In other cases, we may wish our support devices to help us to regain a starting position after movement has occurred. These dynamic postural alteration properties are of particular importance around the trunk since it is this part of the body which will facilitate or impede the greatest number of our seated activities. To understand the pros and cons of these different 'dynamic' situations allowing postural variation, this article has coined some terms to help differentiate the different aspects.

Importantly, safety has to be a primary concern. Not all movement is good. There are instances where a desired postural adjustment is both protected and facilitated by restricting the movement of other parts of the body. Indeed, by not permitting restricting certain movements, the outcome can be very dangerous and even life-threatening.

**Safety – Placement of supports**

In different parts of the world, deaths from strangulation by anterior harnesses have been recorded. Strangulation can arise because the support is too high and it occludes the airway. This can be because the support has been fitted too high, or the support has been adjusted since fitting and consequently sits too high, or the support has moved out of position since being fitted. The risk of injury or death due to strangulation is greater when a chest support is used, as compared with a shoulder harness, due to the neck shape integral to the design of the support. To remind users of this risk, a label has been recommended (Figure 1) in the recently published ISO/TS 16840-15[1]:

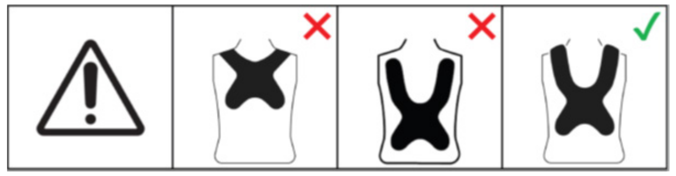

**Figure 1. Anterior trunk support label**

Alternatively, the risk of strangulation can arise because of the misapplication of other postural support devices. An anterior trunk support should never be used without a properly positioned and adjusted pelvic positioning belt (again see ISO/TS 16840-15[1]). The occupant might be able to slip down in their seat if their pelvic positioning belt is absent or not in use, fixed too loosely, poorly positioned, or malfunctioning.

The occupant collapsing down in the seat, and the airway being occluded by the support can also occur because there is insufficient lateral trunk support such that the occupant collapses to one side; or there is insufficient posterior pelvic or lumbar-thoracic support to maintain an upright posture, so that the occupant collapses down into a kyphotic posture.

The risk of injury or death is increased when the occupant is unable to recognize that something is incorrect about their seating or cannot verbally communicate their distress.

**Safety – Dynamic materials**

Another risk comes from mechanical compression to the ribcage or diaphragm due to the anterior support being fitted too tightly, or the occupant sliding underneath the postural support until stopped by their arms and ribcage, placing pressure on the ribcage. A degree of elasticity in the support materials will allow movement of the diaphragm and thus not interfere with respiratory movements of the thorax. Harnesses incorporating such materials are what we might call **reactive** dynamic devices. However, it is important as to where the reactive elasticity is positioned and directed.

**Figure 2 Stayflex chest harness ('male' and 'female' versions)**

'Butterfly' harnesses made from elastic materials like Lycra have been found not to meet the ISO 16840-3[2] performance standard. They have been found to rise up with the chest movements, and reports of strangulation have resulted. This risk has been removed in alternative chest harness designs such as the Stayflex (Figure 2), where the materials and stitching allow only vertical stretch of the straps over the shoulders, and only lateral stretch in the webbing attaching the lower part of the harness, but no stretch in the central zone. An alternative can be found in the Posigo FLO2 (Figure 3) where the lower straps have the elasticity to allow the diaphragm full movement. (Both models have solutions for male vs female torsos.)

**Figure 3. Posigo FLO2 anterior harnesses ('male' and 'female' versions)**

### Permissive Dynamism

Depending on the core strength of the trunk, the occupant may be able to move away from their centrally balanced position, but only a limited distance for specific body segments before the effects of gravity become stronger than the individual's ability to recover their original position. In this case the occupant might desire a **permissive** dynamic support which allows postural adaptation, but only to the distance where the ability to recover to an original position can be achieved. The degree of tightening and the elasticity of the upper straps of an anterior harness might be one way of achieving this.

### Responsive dynamism

A permissive dynamic support may help to keep the torso within a range of movement. As the occupant tires they may need increased assistance in regaining their 'neutral' position. Elasticity within the device or spring mounts attached, i.e. a **responsive** dynamic support, can help here, but may need individual selection to match that particular user's needs. An obvious candidate is an anterior harness where the elasticity in the upper straps helps the occupant back into their posterior support.

An innovative approach is the EPiC seating system, where the back support is mounted with gas struts which can be set up to allow the occupant to push back into a more reclined position, and then assists them to return into a more neutral/resting position as desired (Figure 4). Another product in this category was the Hip Grip (now discontinued), where a support around the pelvis allowed the occupant to move their pelvis towards a more anterior pelvic tilt, while rubber springs in the device helped the individual to regain their original posture. The success of both these latter products was that they were designed to articulate around the body's natural pivot point of the hip joint (traditional back support recline mechanisms rotate at the junction of the back support mounts and the seat base, which is quite some distance below the position of the hip joint!). For the EPiC, this provides the additional benefits of no shearing along the person's back during the recline. Importantly, any lateral, anterior, or head supports remain in place relative to their alignment with the occupant's body.

**Figure 4. The EPiC seating system**

### Absorptive supports

Another family of dynamic systems are those which are designed to **absorb** the energy dissipated into the seating and chair components from high tone occupants. These are usually spring-loaded to return the component to its original position. This may apply to a single component, as seen in the likes of the Stealth's Tone Deflector (Figure 5), or Symmetric Designs' Dynamic + addition to their Twin Headrest Hardware (Figure 6). Alternatively, this may apply to multiple components which allow the back support-seat and the seat-leg support angles to open up as the occupant extends, and then springs bring the elements back into their original position as the occupant relaxes. There are also absorptive support materials which may aid in absorbing the energies of the fatiguing vibrations experienced when propelling a chair over uneven ground. Research has shown, for example, that air-foam cushioning in the seat cushion and back supports absorbs vibrations better than solely air or gel cushioning.

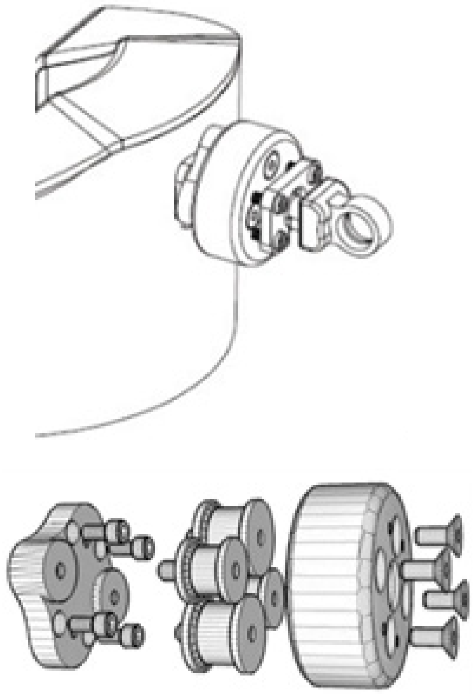

**Figure 5. Stealth's Tone Deflector**

**Figure 6. Symmetric Designs' Dynamic + tone deflector**

### Active dynamism

The most **active** dynamic system is one that reacts to sensors which detect the position of the body and then applies energy to the system to adjust the person's posture. This can be a response to an elevated pressure being in place for longer than the system's algorithms indicate that it is safe, and air cells, for example, are respectively deflated and inflated so that the pressures are redistributed elsewhere. There are other active dynamic systems which sense that the body's mass has moved offline (maybe as a consequence of fatigue), and actuators come into play which push against parts of the torso or seat to bring the occupant's body back into line.

### Conclusion

There's a range of concepts of 'dynamic' within upper body management in a seating system: each is important in its own right. Depending on the client's need the dynamic element may be Reactive, Permissive, Responsive, Absorptive, or Active – or a combination of one or more of these. They each have impacts on a person's postural variation, and to different degrees. Part of the specialist's seating assessment is to ascertain what the client wants to achieve through their day-to-day activities, and which dynamic aids will facilitate this postural variation to meet these requirements, thereby enabling seating as an activity.


1. *BS ISO/TS 16840-15:2024 Wheelchair seating — Part 15: Selection, placement and fixation of flexible postural support devices in seating*
2. *BS ISO 16840-2:2022 Wheelchair Seating – Part 3: Determination of static, impact, and repetitive load strengths for postural support devices*

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**By Dr Barend ter Haar**

# What makes a good trunk support?

## 3. Measurement to fit

**For a trunk support to be effective it needs to be the right size. Here we look at the measures involved for the accurate prescription of anterior and lateral trunk supports.**

Manufacturers have traditionally ascribed sizing to their flexible postural support devices (PSDs) with letters (e.g. S, M, L) rather than numbers. However, one manufacturer's medium (M) is not necessarily the same as the next manufacturer's. To overcome this challenge, the recently published ISO/TS 16840-15[1] (the replacement for the older British standard BS 8625) has prescribed a standardised nomenclature for manufacturers to use when showing the size that will be appropriate for an individual client. The annexes to this standard cover a range of flexible postural support devices, but here we will consider just trunk supports. Annex A of the standard summarises the measures of the client, and Annex B the PSD measures to match the client.

Selecting the right size and type of anterior support, and choosing the correct placement is (aside from achieving the desired clinical outcome), critical to the health and safety of the client. Getting this wrong might lead to strangulation at worst, but also harm, such as skeletal deformation (e.g. misalignment of the spine) over time. The devices can either facilitate or impede bodily internal function and external activities, depending on their type and placement – the benefits of different aspects of dynamism were covered in Part 1. Never to be forgotten is that, for safety, a correctly positioned and adjusted pelvic positioning belt is essential before considering any upper body support.

### Client measures for flexible PSDs

There are three types of anterior supports commonly available – shoulder harnesses, chest harnesses (for examples see Figure 1), and circumferential harnesses. For the shoulder and chest harnesses, the shoulder width should be measured as shown in Figure 2. This width is used to prescribe the size of the support.

**Figure 1. Examples of a shoulder harness and a chest harness**

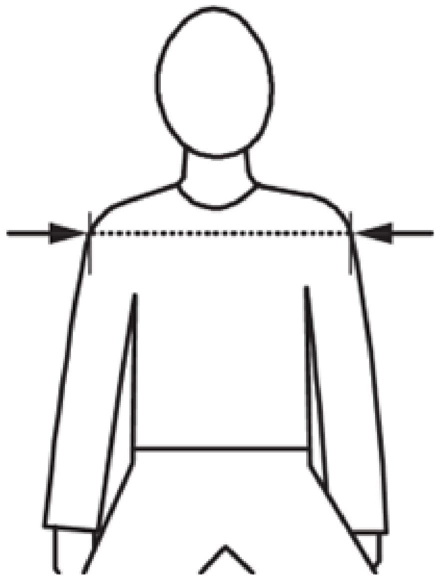

**Figure 2. Measurement for an anterior trunk support (Fig A.6 from ISO/TS 16840-15[1])**

In contrast, circumferential supports are the most flexible of the flexible PSDs, and do not involve straps over the shoulders – for examples see Figure 3.

**Figure 3. Examples of circumferential trunk supports**

Circumferential supports are used most commonly around the chest, where the rib cage protects the internal organs. Sometimes it will be necessary to support the soft tissues of the upper body which will involve mounting across the abdomen. Where an abdominal support is used, often this is to provide support, for example, for sagging abdominal muscles, strengthening abdominal muscles and weakened abdominal walls, reducing pain while laughing, avoiding discomfort while coughing, avoiding squeezing or cramping up of muscles, or assisting toning of abdominal muscles.

The circumferential distance needs to be measured with a flexible tape around the torso, from the back support upright on one side to the upright on the other side (Figure 4), at the height where the support is to be applied, to prescribe the appropriate size of support.

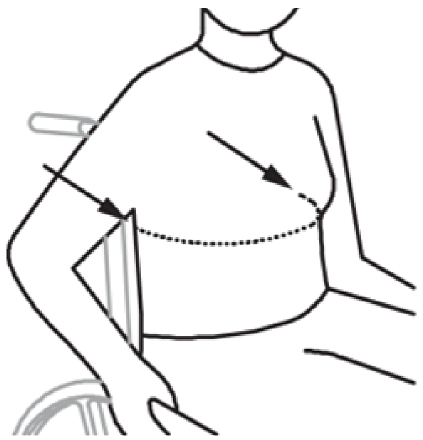

**Figure 4. Measurement points for a circumferential chest support (Fig. A.7 from ISO/TS 16840-15[1]}**

### Measures of flexible PSDs

An anterior trunk support shall be described by the range of shoulder width measures (Figure 2) for which it is designed. The shoulder width range for which the PSD is suitable becomes the 'size' of the PSD. If the selected shoulder width size range were, say, 250 to 290 mm, the PSD size would be 25-29. Further examples are given in Table 1.

Table 1 — Anterior trunk support size selection

| Anterior trunk support size | Designed for shoulder width | Possibly described previously as |
|---|---|---|
| Size 15–24 | 150 mm to 240 mm | XX Small |
| Size 24–28 | 240 mm to 280 mm | X Small |
| Size 28–33 | 280 mm to 330 mm | Small |
| Size 33–41 | 330 mm to 410 mm | Medium |
| Size 41–48 | 410 mm to 480 mm | Large |
| Size 48–55 | 480 mm to 550 mm | X Large |

The same principle applies to a circumferential chest support, the size of which is derived from the range of chest measures for which it is designed. Examples are given in Table 2.

Table 2 — Circumferential trunk support size selection

| Chest support size | Circumferential measure of person's trunk | Possibly described previously as |
|---|---|---|
| Size 31–41 | 310 mm to 410 mm | X Small |
| Size 40–49 | 400 mm to 490 mm | Small |
| Size 47–58 | 470 mm to 580 mm | Medium |
| Size 55–66 | 550 mm to 660 mm | Large |
| Size 62–73 | 620 mm to 730 mm | X Large |

### Rigid supports

Most anterior supports are flexible in design to fit around the curves of the torso, but also need to allow a degree of movement for breathing and functional activities (all of which tend to be mostly in a forward direction). Circumferential supports will also supply a degree of lateral support and lateral movement.

Conversely, for stability of the upper body, most lateral and posterior supports are based on rigid structures. Being rigid structural items, primary measures will relate to their respective positions in space and relate to their points of fixation on the seating system or chair. The size of the pads on the supports will be important, but not as critical as the sizing for a flexible support. Back supports will have some aspects of lateral support, but for now let's cover standalone lateral trunk supports. (Describing the measures and positioning of posterior (back) supports is covered in Parts 4 and 5 of this series.)

### Lateral trunk supports

Lateral trunk supports can be prescribed for different purposes. At the more simple level, they provide lateral boundaries to help position the trunk in the midline. The body measure for these will relate to the width of the trunk at the height at which they will be mounted. The support will usually be located alongside the ribcage to avoid interaction with soft tissues, but not too high as to impede arm movement or cause discomfort.

To provide information to the person placing the support onto the seating system or chair, the point at which the centre of the support surface touches the occupant is a point in space that is measured from the 'zero point' of the seating system. The zero point is designated as being at the junction of a vertical line down the centre of the surface of the back support with a horizontal line along the centre of the surface of the seat cushion (0,0,0s in Figure 5). The height of the PSD will be the height from the zero point to the centre point of the surface the PSD ($Y_3$). The 'depth' will be the distance forward from the zero point ($X_3$), and the width will be the sideways distance from the zero point – a positive value if to the right of the chair and a negative value if to the left.

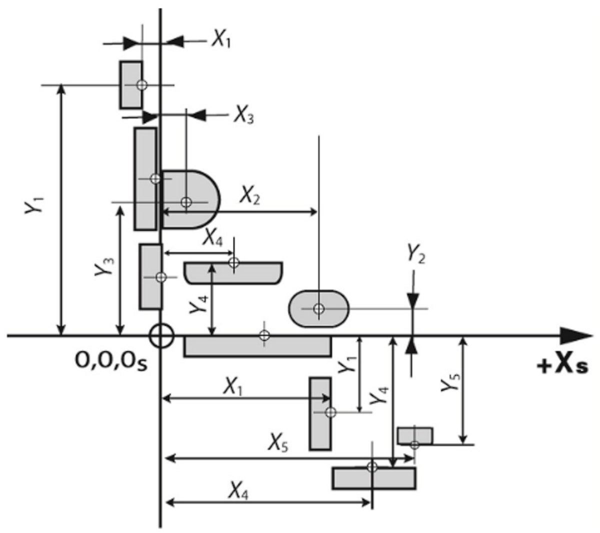


**Figure 5. Height and depth location measures of PSDs**

### Adjustable lateral trunk supports

For a retaining role, the pads are usually mounted parallel with the 'orthogonal' axes of the seating system, i.e. with the X, Y, and Z axes. However, when the pads are being used as positioning devices to accommodate or correct scoliotic deformities of the spine, it is critical that the pad mounting systems allow the pads to be both positioned and angled to push along the line of the rib in its direction towards the vertebra where the positioning action is required. In these instances, a vertical pad would push the rib in the wrong direction and exacerbate the scoliosis. Examples of systems which allow 3-dimensional positioning in space of the PSD pad are Symmetric Designs' Lateral Upper Body Support (LUBS) and Stealth's Full Surface Contact pad mount (FSC) (Figure 6). A further benefit of the pad of the LUBS is that it can be conformed to the occupant's body shape around the point of contact.


**Figure 6. The Symmetric Designs' LUBS and Stealth's FSC lateral support mounts**

Guidance as how to measure the required angle of the support in three dimensions is provided in Figures 5 to 7 in the THIIS June 2023 article[2] in the Measurments in Seating series.

### Conclusion

A full assessment of the client's physical and functional needs and abilities will dictate what is the most appropriate postural support device for that client. Obtaining the appropriate measures of a client, and then selecting and correctly positioning the respectively appropriate postural support device(s) is critical for the safety and long-term health of the client.

1. *ISO/TS 16840-15:2024 Wheelchair seating — Part 15: Selection, placement and fixation of flexible postural support devices in seating*
2. *THIIS June 2023 Measurements in Seating 4. Absolute angles in seating system measures (downloadable from https://hiaus.net.au/knowledge-hub/measurements-in-seating-4-absolute-angle-seating-system-measures/ )*



BES HEALTHCARE

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**By Dr Barend ter Haar**

# What makes a good trunk support?

## 4. Back support measures

**Within a seating system, the primary support surfaces are the seat cushion and back support. What are the measures of a back support that offer up a good fit for the occupant?**

Many accessories to a seating system are two-dimensional and therefore are easy to describe and to measure. Back supports tend to be more complicated because most offer a mix of posterior and lateral support, with differing functional needs at different points along the length of the upper body.

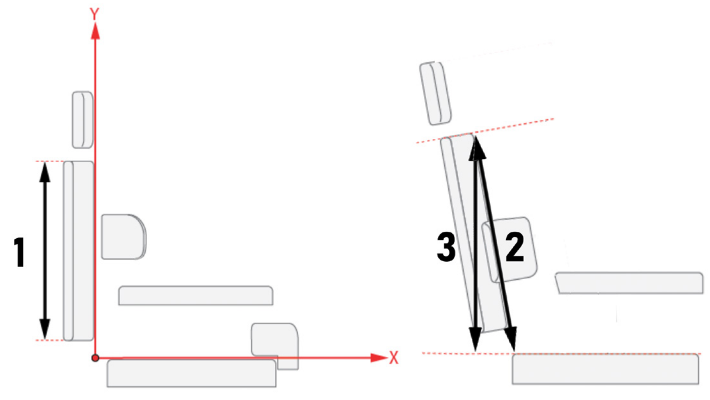
Back supports are usually prescribed to support different, but at the same time, 'articulated' parts of the body. The back bone of the trunk is a collection of separate components, the vertebrae, most of which can articulate to a degree in three dimensions, and therefore each of which has an individual degree of need of support. These separate, but connected, components all provide for flexibility of body position, but at the same time provides multiple areas where intervention and support may be required to prevent deterioration or damage – hence the need for a back support that can manage these components while permitting the greatest degree of freedom.

### Back support measures

Managing these needs is the remit of the prescribing individual, but how can the manufacturer describe the measures of the different elements of the back support so that the prescriber knows which one to order? The ISO wheelchair seating standards task group has come up with a series of terms and their definitions for complex seat cushions, and these will be part of the revision of ISO 16840-1[1] when it gets published (if the reader wants more detail of these in the meantime, please drop me an email at barend@beshealthcare.net). However, to date there has not been a recommendation for the terminology for even basic back supports, and the intent of this article is to put some suggestions forward.

The complexity, for even the more simple back supports, is the range of components involved. This includes i) the mounting hardware (which pertains to the wheelchair's dimensions), ii) the back support supporting structure (e.g. shell), and iii) the attached back support cushion (which pertain to the occupant's dimensions). The existing standardised terminology covers the basic starting points. Width is the size dimension from left to right. Depth is a front to back size dimension. Length is a top to bottom size dimension. Thickness is the size dimension under and at right angles to the support surface itself. Height, on the other hand, is a placement measure and is defined as the distance from the top of a reference point on the back support component to a fixed point elsewhere.

For example, the back support out of the box has a length (Figure 1, 1), but does not have a height until it is attached to the chair: at this point, the height is the distance from the top of the back support to the top of the seat cushion (Figure 1, 2) at whatever angle the back support is reclined. This is not to be confused with the vertical height which is important to see if the chair will fit into a vehicle, for example, and which is the vertical distance from the top of the support to a horizontal projection from the top of the seat cushion (Figure 1, 3).




*1 Back support length*
*2 Back support height*
*3 Back support vertical height*

**Figure 1. Back support length and height dimensions**

### Mounting hardware dimensions

Some wheelchairs have their back supports mounted on a central pillar, often known as a Captain's seat, and which is more common on scooters. However, most wheelchairs have a pair of vertical poles which are usually placed as far apart as the tubing of the seat support structure. It is this width that is normally ascribed to the 'width' of the back support.

The existing standard for wheelchair dimensions, ISO 7167-7[2], defines as Dimension 8 the back support structure width as the maximum width at a height between 200 and 500 mm from the seat surface on a loaded chair. However, the illustrative figure (Fig. 17) suggests the points for measurement on each side of the chair are from different parts of the tube, depending on where an existing canvas is attached. This standard is being revised, and the proposal is that the chair back support structure width be stated as being the maximum distance across the outside of the uprights (Figure 2). This measure in the standard is currently made after the chair seat has been loaded with a weighted dummy since the distance between the uprights can decrease in folding chairs, though is less likely in chairs with a rigid frame.

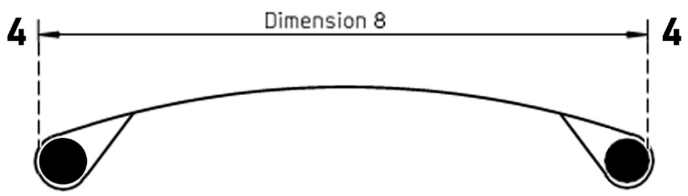



**Figure 2. Seat frame width (4 to 4: "Dimension 8") measure (view from above)**

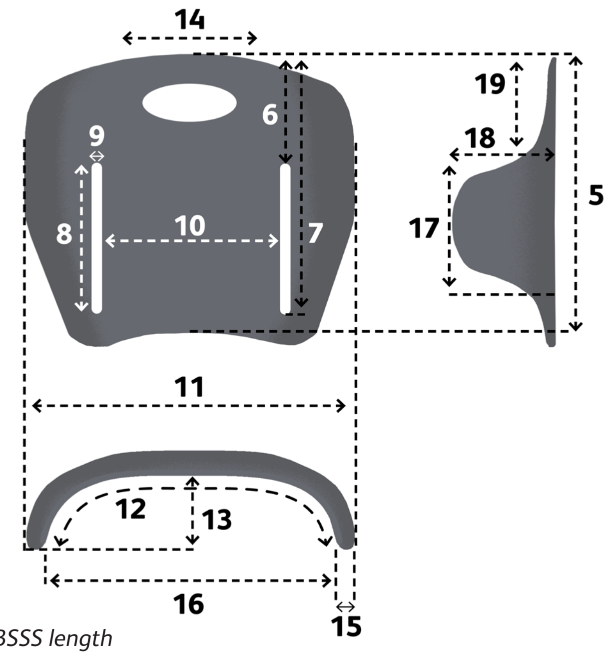
If the back support is mounted in front of the uprights, then the support itself could in practice be wider than the distance between the uprights: otherwise it will need to be narrow enough to fit between the poles, which will be the 'Dimension 8' less the diameter of the poles.

These days most back supports are supplied with 2-point mounting options to accommodate the paucity of space on the uprights for 4-point mounting systems, especially for back supports with a short length. Many hardware mounting systems have built into them adjustability for variations in width, height, and angle. These should be described by the manufacturer in mm and degree ranges respectively. In some cases, width and height adjustments are provided in addition or alternatively by slots in the back support support structures. The width adjustability not only accommodates for variability in the upright poles' width variability, but also allows the back support to be mounted in an offset position, if needed to accommodate a scoliotic spine, for example.

### Back support support structure

The back support support structure (BSSS), is usually a board of some type in a planar (flat) seating system, but in most cases it is a 'shell'. The BSSS provides the means to have the back support attached to the mounting hardware on the one side, and the back support cushion on the other. The shell structure measures are likely to be slightly smaller than the attached cushioning so that the occupant is protected from injury from the edges of the shell. The BSSS is also the structure to which ancillary support items such as anterior, lateral, or head supports are attached.

The key measures for the BSSS are going to be a mix of its linear 2-dimensional measures, its surface measures, and the measures of any additional elements for both mounting hardware and also for other accessories. Figure 3 provides illustrations of key measures and suggestions for relevant naming for a standard shell. Where the shell has integrated elements for additional lateral support, these should be ascribed additional measures to cover their attributes (Figure 3, 17, 18 and 19).



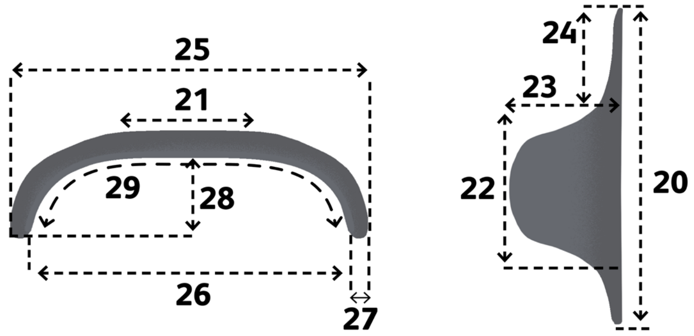

*5 BSSS length*
*6 Height from bottom of BSSS vertical slot*
*7 Height from top of BSSS vertical slot*
*8 Length of BSSS vertical slot*
*9 Slot width*
*10 Internal slot width*
*11 BSSS maximum external width*
*12 BSSS internal semi-circumferential width*
*13 BSSS depth*
*14 BSS posterior planar width*
*15 BSSS thickness*
*16 BSSS internal width*
*17 BSSS integrated lateral support length*
*18 BSSS integrated lateral support depth*
*19 BSSS integrated lateral support height*

**Figure 3. Measures of aspects of a back support support structure (BSSS) from in front, side (17-19), and above (12, 13, 15, 16)**

### Back Support Cushion

The back support cushion is the interface between the occupant and the back support, and so these measures are the ones that are needed to meet the relevant measures of the occupant.

From the posterior aspect, the amount of support needed is a limited width (Figure 4, 21). If a pressure mapping system is used to assess the surface contact on a planar back support, the contact surface is unlikely to be more than 200 mm wide. However, most back supports are wider than this to accommodate the back support mounting system, to enable the addition of further positioning accessories, and usually to provide some lateral support to a lesser or greater degree.




*20 BSC length*
*21 BSC posterior planar width*
*22 BSC integrated lateral support length*
*23 BSC integrated lateral support depth*
*24 BSC integrated lateral support height*
*25 BSC maximum posterior width*
*26 BSC internal width*
*27 BSC thickness*
*28 BSC depth*
*29 BSC internal semi-circumferential width*

**Figure 4. Measures of elements of a back support cushion (BSC) from above (21, 25-29) and from the side (20, 22-24)**

### Practicalities

These measures are suggestions to cater for off-the-shelf after-market back supports, and are therefore not applicable to more custom-seating solutions such as foam-carve or FreeForm (Figures 5) types of supports. They cover linear measures on the whole and relate mainly to items as supplied by a manufacturer.

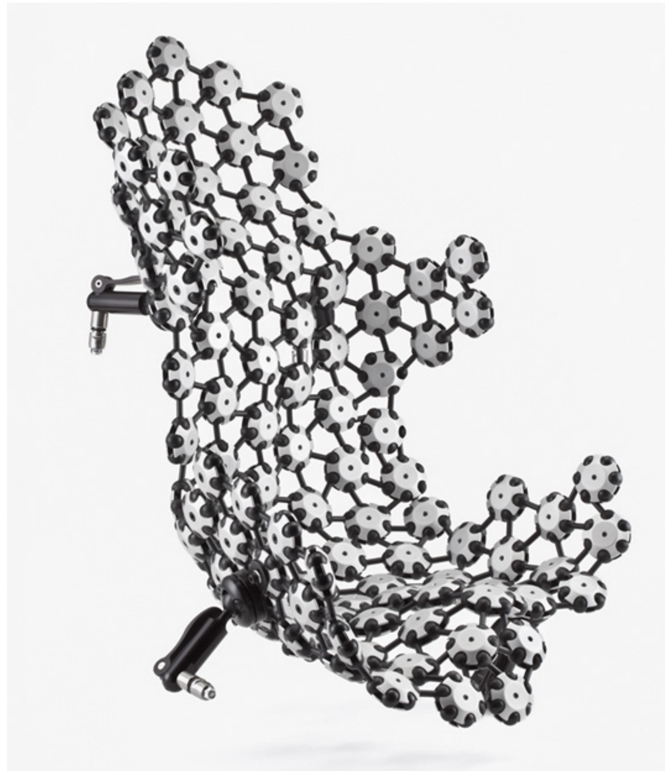


**Figure 5. The Symmetric Designs FreeForm customisable modular back and seating system.**

In Part 5 we cover measuring the individual to enable us to prescribe the most suitable product match for the individual's dimensions, as well as selecting the appropriate back support and set-up for that individual's needs. Part of the set-up includes selecting the appropriate angle for placing the supports on the wheelchair frame. The foundations for these measures were covered in previous articles, in the Measurements in Seating series. Further guidance can be found in Waugh and Crane's Clinical Application Guide to the ISO 16840-1 measures[3].

1. *ISO 16840-1:2006 Wheelchair Seating — Part 1: Vocabulary, reference axis convention and measures for body segments, posture and postural support surfaces*
2. *ISO 7176-7:1998 Wheelchairs — Part 7: Measurement of seating and wheel dimensions*
3. *Waugh, K and Crane, B (2013) A clinical application guide to standardized wheelchair seating measures of the body and seating support surfaces. Accessible as BPG3 from https://www.pmguk.co.uk/resources/best-practice-guidelines/bpg-archive*

**Let's Get It Clear No. 69**
**First published in THIIS March 2025**
**By Dr Barend ter Haar**

# What makes a good trunk support?

## 5. Back support prescription

**Within a seating system, the primary support surfaces are the seat cushion and back support. In this part we discuss the relevant measures of the occupant needed to prescribe the most appropriate back support.**

Selecting the correct back support dimensions, and prescribing the correct placement of the back support, are critical to the wheelchair occupant's functionality. In Part 4 of this series, we addressed the core measures of a back support itself as they relate to the dimensions of the occupant: these go well beyond the normal back support sizing dimension used which relate to the size of the wheelchair. In this article we address the measures of the occupant which match up with the back support measures, but also reflect on the placement of the back support to give support to relevant parts of the upper body.

**Back support height and length**

As a starting point for managing the upper body, we need to make sure that the lower body is positioned correctly. Are the feet far enough back so that the upper part of the lower legs are not pulling on the hamstrings to pull the pelvis into posterior tilt? Are the thighs and pelvis stabilised and positioning aids such as a pre-ischial ridge in the cushion and correctly placed pelvic positioning belts in place? (For advice on these aspects see other articles in the THIIS Let's Get It Clear series.)

Part of our pelvic positioning aims is to manage the degree to which the pelvis can rotate in the backward/forward direction. Some degree of pelvic posterior tilt is desirable for comfort and relaxation, but the more the tilt the more likelihood there is of kyphotic compensation in the spine, and with time this amount of compensation can become fixed. To control the degree to which the pelvis can rotate backwards a 'block' behind the PSISs at the top of the pelvis is an ideal tool. This is where the bottom of the back support can come into play if positioned at the level of the PSISs.

From here, we have a starting point for calculating the required length (vertical dimension) of the back support, and to do this, we need to work out the required height. (As a reminder, the length is the distance from the top to bottom of the back support. It does not have a height until it is placed on the chair, when the distance from the top of the back support can be measured to a reference point – usually the top of the seat cushion.) Most back supports that are prescribed are longer than they should be for the purpose of supporting the spine posteriorly (Fig.1). Any of the back support that goes above the highest posterior curvature of the spine is not supporting the back, but just adding weight to the chair. Importantly, this extra length, and therefore height, can also impede the occupant's upper body movements.

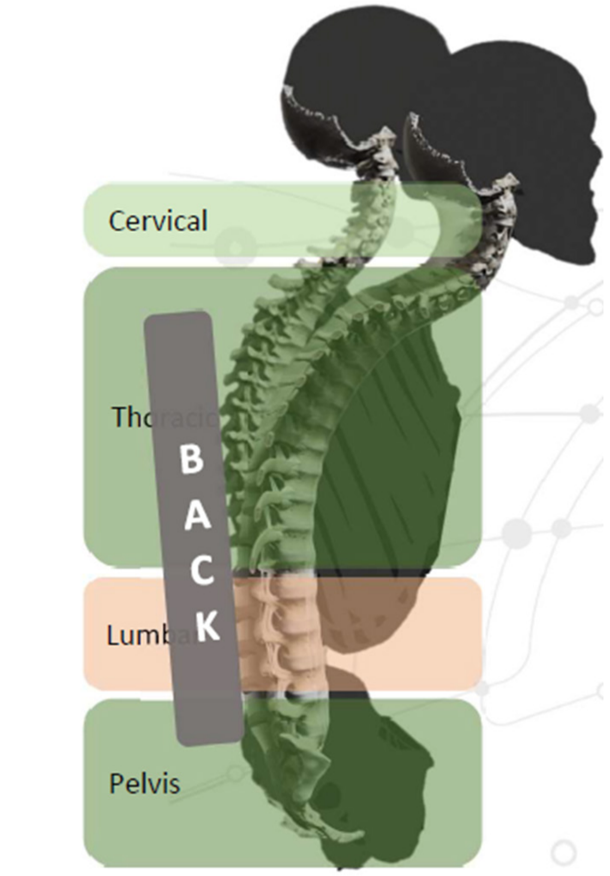



**Figure 1. How much of the back support is supporting the back?[1]**



We have twelve thoracic vertebrae numbered T1 to T12 from the top. Anything in the T3 to T8 zone will impede movement of the shoulder blades, the scapulae. For the average person the top of the back support probably does not need to go any higher than being level with T7: this then gives us a typical length needed for the back support to cover the distance from the PSISs to T7, of around 33 cm (Fig. 2).

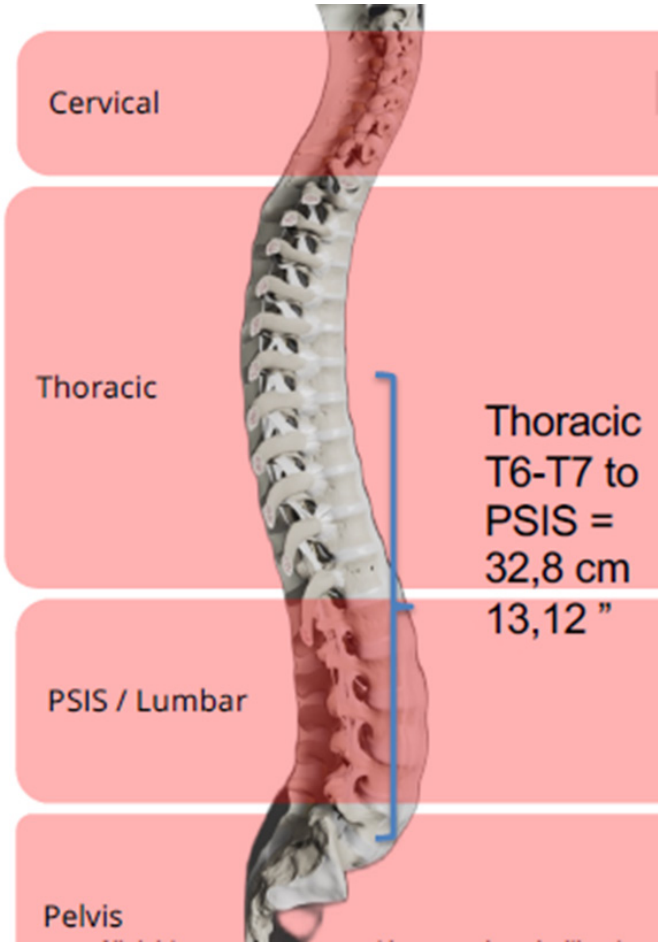



**Figure 2. Distance from PSISs to apex of spinal thoracic curve[1]**

**Is there a need for this extra height?**

So why do we prescribe these longer back supports? The first reason might be the advice that any anterior supports need to be attached horizontally across the top of the shoulders. This can, however, be achieved with a lower height back support by means of items such as Bodypoint's Strap Guides (Fig. 3), or Symmetric Designs' Strapparatus (Fig. 4).

A second reason might be the need for a head support, since this is usually attached via a mount on the back support. By choosing one of the modular mounting systems available on the market from the likes of Symmetric Designs (Fig. 4) or Stealth Products (Fig. 5), it should be possible to mount the head support on a shorter back support.

**Figure 3. Bodypoint's Strap Guides for mounting anterior supports**

**Figure 4. Symmetric Designs' Strapparatus for anterior support mounting and extended height head support mounting**

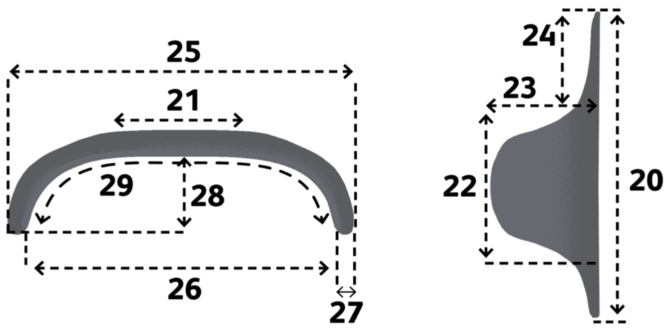
**Figure 5. Stealth Products Unilink mounting system**

A third reason is that the wheelchair is going to be used in a motor vehicle with the occupant in the chair. In this case the chair needs to be crashworthy, as well as its seating system. The current crash tests in ISO 7176-19[2] for wheelchairs and ISO 16840-4[3] for seating systems originated from a philosophy that concentrated more on protecting other occupants in the vehicle and less on the wheelchair occupant's needs. They were also developed in the days before the current ranges of after-market 'accessories' from independent manufacturers were available. The result is that the current test set-ups tend to give a crashworthy certificate to a basic chair without accessories in place, unless they are built into the chair in the first place. They do not cover for an after-market head support on a short back support as being a viable means to control upper body "excursions" during the test procedure, for example.

The ISO standards working groups have now started to address this, but currently there are no prescribed crash tests for back supports, head supports, etc on their own. The end result is that the prescriber needs to carry out an individual risk assessment for each client's situation and needs, and cannot fall back on a there being a crashworthiness certificate.

**Back support width**

Figure 6 presents various relevant measures of the back support cushion for an individual. For pure posterior back support, dimension 21 (planar width) covers the width needed for a planar posterior support on its own, and would cover the width of contact of the back with a flat board.




*20 BSC length*
*21 BSC posterior planar width*
*22 BSC integrated lateral support length*
*23 BSC integrated lateral support depth*
*24 BSC integrated lateral support height*
*25 BSC maximum posterior width*
*26 BSC internal width*
*27 BSC thickness*
*28 BSC depth*
*29 BSC internal semi-circumferential width*

**Figure 6. Back Support Cushion (BSC) measures**

However, most people prefer a degree of lateral support as well. The internal width (dimension 26) provides the maximum width of the torso with the lateral elements included, usually measured around the T11/T12 area of the trunk. Depth (dimension 28) gives a measure to which the lateral support wraps around the trunk: the greater the depth, the more support but the less degree of freedom. Further lateral support can be provided by integrated lateral supports (dimensions 22-24) or by externally mounted lateral supports on one or both sides.

These back support cushion measures will then relate back to the back support support structure (BSSS) as summarised in Part 4 of this series. The BSSS measures will usually be less than the cushion measures to allow some overlap of the cushion padding to stop the support edges harming the occupant.

The major implication from the width measures will be on how far back the back support can be mounted before it has interference from the back canes on the wheelchair itself. Some chairs and some back supports offer central mounting options, and then the limit comes from how far back these mounts will allow the back support to be mounted. For a manually propelled chair, the further back the back support is mounted, the more access there will be to the wheel rims. However, this is countered by the risks of moving the centre of gravity of the system too far back for safety.

**Back support angle**

There is much debate currently about the benefits versus the challenges of tilt and recline in seating systems. This is addressed in more detail in Part 6 in this series. In brief, if the bottom of the back support is placed at the PSISs, it will need to be reclined from the vertical to accommodate the kyphotic curvature around the thoracic vertebrae and possibly the scapulae – otherwise the occupant's upper body will be pushed too far forward, and they will need to accommodate this position with cervical extension at the neck to be able to see what they are doing. For those with greater degrees of kyphosis, simply by setting up the back support with an increased angle of recline can reduce the amount of hyperextension required at the neck.

1. *Figures 1 and 2 courtesy of Bart Van der Heyden, PT / SuperSeating*
2. *ISO 7176-19:2022 Wheelchairs — Part 19: Wheelchairs for use as seats in motor vehicles*
3. *ISO 16840-4:2009 Wheelchair seating — Part 4: Seating systems for use in motor vehicles*



**Let's Get It Clear No. 70**
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**By Dr Barend ter Haar**

# What makes a good trunk support?

## 6. Postural Variation

**Different postures are required for different activities. In this part we review the impacts that different postures have on the seated occupant, and the impact that adjustments to their seating system can have on the occupant's functionality.**

Sitting is an activity, and postures will change during the day to accommodate for fatigue, changes in tone, etc, in addition to the changes needed to achieve functional activities. Functional movements during wheelchair use such as head and upper extremity movements are most effectively executed when multiple body segments are involved, so we need to be able to vary our postures to achieve our required outcomes.

Adjusting the position of one part of the body frequently has an impact on at least one other part of the body, often a good distance apart. When you look up to the ceiling when seated, you will need to extend your neck, i.e. your cervical spine - but extending the neck can also be assisted by some extension of the thoracic or even lumbar and pelvic segments. Conversely, changes in your foot position may have an impact on your head's position.

Other impacts can occur from proximal changes such as reclining the back support or tilting the seating system, where even a small change can have a large impact on the effectiveness, or even safety, of various seating accessories.

**Tilt in space**

Tilt in space has often been recommended as a means to reduce the pressures on the occupant's ischial tuberosities, the bony parts on the base of the pelvis, but to achieve this the seating system needs to be lilted back at least 30 degrees: this may be a great position to relax in, but otherwise is not very functional. With tilt in space, the orientation of the seating system components that are attached to the seating system (as compared with being attached to the frame of the wheelchair) and therefore sections of the body, stay fixed, but the orientation of the whole body changes.

The part of the body that tends to be affected most is the head since the occupant is left staring at the ceiling initially. To be able to react with their surroundings they then make postural adjustments, such as flexing their neck to adjust their line of sight (Figure 1). This can lead to greater trunk flexion into the back support which in turn can result in the pelvis being pushed forward. Ultimately the occupant will probably need an assistant to help them reposition themselves.

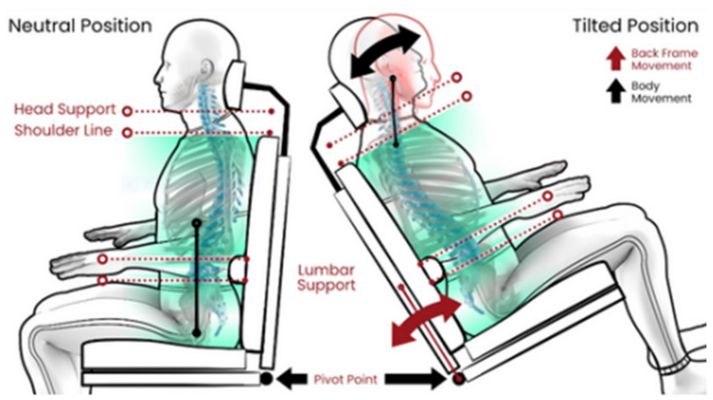


**Figure 1. Impact of tilt in space on body posture**

**Recline**

A common postural adjustment device on a seating system will be the recline function. This is where the most frequent problems occur: the fulcrum point for the device is usually at the junction between the back support and the seat – which is not level with the fulcrum of recline in the occupant's body, which is the hip joint (Figure 2). The result is that during recline there are shear forces between the occupant's back and the seat's back support as the two move different amounts relative to each other. At the same time accessories attached to the back support, such as lateral or head supports, will move up the trunk and out of position relative to the part of the body they are supposed to be supporting. In addition, with the pelvis being rotated into a greater posterior tilt, there is a risk of the occupant sliding forward on their seat, thereby also adding frictional and shear forces under the buttocks.

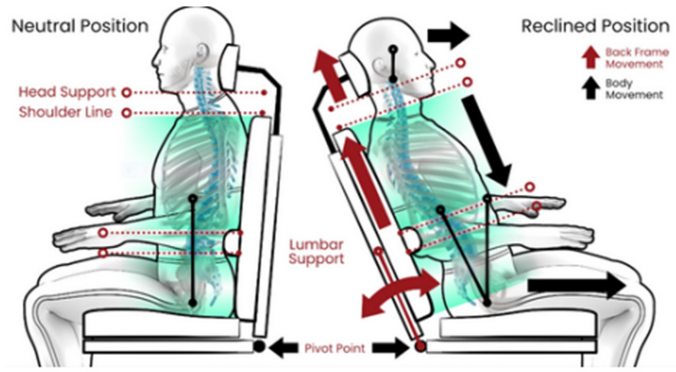


**Figure 2. Impact of back support recline on the body**

In the past, the shear forces on the occupant's back have been addressed by the back support material being on rollers and allowed to move with the occupant's body, but this did not address the positioning challenges. Biangular back supports allow for just static separation of the pelvis from the trunk. Recently an innovative approach has been made available in the EPiC seating system, which allows for dynamic separation of these two parts of the posterior support, where the recline pivot point is aligned with the body's pivot point of the hip joint (Figure 3).

**Figure 3. The EPIC seating system allows the back support to rotate in harmony with the occupant's body**

The result is that while the pelvis to thigh angle is maintained, the lower and mid-thoracic areas can move backwards. The lumbar spine will follow and extend without direct force on the stiff lumbar spine. This innovative approach and movement enables spine extension with minimal shear and friction at the occupant-back support interface and the occupant-seat cushion interface.

Since the movement of the thoracic spine occurs in sync with the occupant's movements there are no shifts in the attached PSDs such as head supports or lateral supports, when this movement occurs. In addition the position of the thoracic spine is crucial for obtaining a functional head position and upper extremity function and helps to reduce the amount of energy needed from postural muscles to sit upright.

There's three optional methods for use:

1. Adjusting, then maintaining an appropriate pelvis to thigh angle for the occupant. This can also be used where the occupant has a hyperkyphotic spine to relieve the degree of neck hyperextension needed to achieve a functional eyeline.

2. Caregiver induced passive postural variation, by allowing the lower and mid-thoracic segments of the back support to move backward (which can be symmetrical or asymmetrical) in sync with the movement of the spine (Figure 4).

3. Occupant induced active postural variation (arising from postural fatigue, upper extremity movements, or tone, for example) causing the lower and mid-thoracic segments to move backwards (symmetrically or asymmetrically), in sync with the movements of the spine, and the gas struts then assist a return into a more neutral resting position as desired.

**Figure 4. An occupant with structural kyphosis and cerebral palsy in a conventional seating system (left) and in an EPiC Seating System (right) - note the head position**



**Upper body extremities**

The back support is the usual mounting point for the head support: aspects to be considered around this have been covered in the "What makes a good head support?" articles in this series.

What about the relationship of the trunk support to the shoulder girdle, arms, and hands? As discussed in Part 5, most wheelchair occupants do not need a back support any higher than being level with the base of the scapulae, because there is normally no contact between the occupant's back and back support above this point (an exception is occupants undergoing high tone extensor spasms, for example). Indeed, a higher-positioned back support will impair the occupant's range of upper body movement, and therefore their functionality.

Of great importance for most people's functionality is the use of their hands, whether for writing, eating, texting, or operating a joystick, for example. An appropriately positioned back support can facilitate this functionality, but on top of this is the back support's physical relationship with the chair's arm supports. This is where there has been a tendency towards inappropriate design.

For most people the anatomically correct, and therefore comfortable position, is to have our hands in front of us, and not rotated outwards along a chair's standard arm supports. The result is that maybe our elbows alone are placed on these supports, and frequently these are not at the appropriate height to support the upper arm correctly in the shoulder socket. Without proper support at this point, occupants (particularly those with reduced joint proprioceptive sensation after, for example, a stroke) end up with subluxed joints and consequent extreme pain. This all could be prevented by early intervention with an appropriately positioned arm support.

One such support is Bodypoint's Dynamic Arm Support (DAS) (Figure 5) which was invented by the renowned Belgian physiotherapist, Bart Van der Heyden (also the inventor of the EPiC seating system!). The DAS provides three points of support – at the elbow, along the forearm, and at the hand, with all parts designed to provide anatomically correct heights and angles of support and movement.

**Figure 5. Bodypoint's Dynamic Arm Support**

The clinical benefits and outcomes include:

- Contracture prevention and management
- Reduction of shoulder pain
- Mitigated impact of abnormal upper extremity tone
- Strength and proprioceptive training of the upper extremity
- Prevent and minimize shoulder subluxation
- Minimize injury to the upper extremity

However, the DAS will only be effective if the positioning of the arm and hand are set up correctly for the occupant, and that any postural variation around the seating system does not affect this set-up. This is equally true in relation to all other functional uses of the hands where upper body positioning is crucial.

**In conclusion**

A good trunk support correctly prescribed and positioned can keep the occupant safe, and can facilitate daily functional activities. Sitting is an activity and involves frequent postural variation. It is important that the elements of the seating system facilitate this variation in a safe and effective way.

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