Measurement manual

Manual of definitions and methods for measuring sitting posture and pressure distribution

In this manual, the definitions and methods that are used in SMS Seating Advice will be fully explained.

First, the definitions and methods for measuring sitting posture will be presented.
Then the actual measuring of the length, width, height and depth of the wheelchair will be covered. Lastly, the definitions and methods of determining pressure distribution will be explained.

1. Definitions and methods for measuring the sitting posture

Definitions developed in Dr. ir. H.A.M. Staarink's book 'Zo zit het!*' are used to determine and record sitting posture.

Figure 1: Angle definitions

Sitting posture has to be measured under load. The seating angle under load and similarly the backrest inclination under load can only be measured using measuring aids. The measuring instruments developed to aid in this procedure are placed between the relevant body surface under load and its support in such a way that a parallel strip protrudes.
A digital spirit level is used to take measurements along the 'projected' body surface.

The seating angle (angle φ)

This is the angle of the seat under load in relation to the horizontal.

- Check that the thighs are properly supported by the seat. If necessary, adjust the footrests;
- Insert the measuring aid under one thigh in the same lengthwise direction as the femur;
- Make sure that the instrument is placed well in front of the ischial tuberosity. Place the digital spirit level along the protruding strip of the instrument and read the value of the angle. This is the angle φ as can be seen in figure 1;
- Repeat the measurement with the other leg. If the value varies by more than 2° then the measurements should all be repeated.

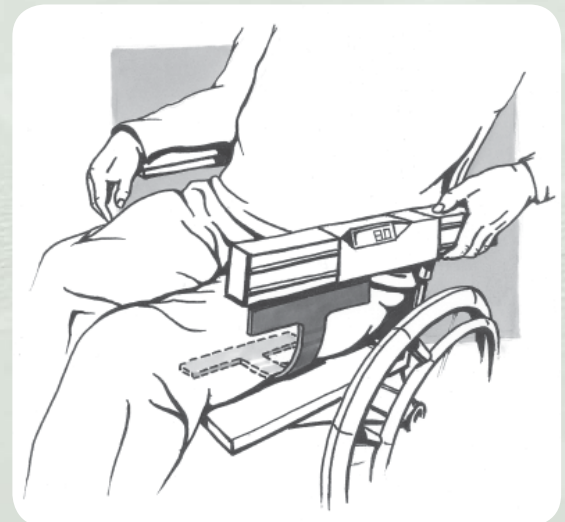*Figure 2: SMS Seating angle bracket*

Figure 3: Measuring the seating angle

* A translation into English, 'All there is to know about sitting, sitting behaviour, seats and wheelchairs' is in preparation.

The functional backrest inclination: angle (φ+α)
This is the angle of the section of the backrest above the small of the back (the lumbar-thoracic transition area) in relation to the horizontal.

- Place the aid between the back and the backrest, to the left of the spine reaching to about 3 cm above the small of the back. The lower 165° bend in the instrument should be placed at about the height of the thoracic kyphosis;
- Place the digital spirit level carefully along the vertically protruding parallel section of the aid and read the value given. If, for example, the value measured is 73°, then the functional backrest inclination, angle (φ+α) is 180° – 73° = 107°;
- Repeat this procedure with the aid placed to the right of the spine. The measurements may not differ by more than 1°. If they do then the whole procedure should be repeated by way of check.
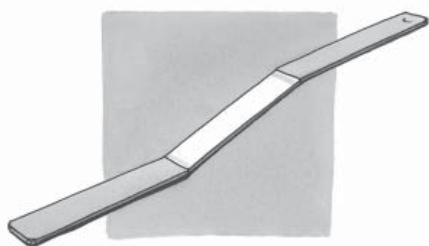

Figure 4: SMS Backrest inclination strip

Figure 5: Measuring the functional backrest inclination

2. Measuring the length, width, height and depth of the wheelchair

These values can only be measured when the wheelchair is empty. When considering the best moment to record these measurements, remember that the number of transfers that the wheelchair user needs to make during the whole session needs to be kept to a minimum.

In the analysis of the current sitting posture, the general idea of how the backrest is positioned with regards to the seat is of great importance. In the first instance, this is checked on the basis of visual inspection/assessment and recorded.

The depth of the seat of the wheelchair
This is defined as the distance from the backrest, measured from where the top of the pelvis would be, to the front edge of the seat (A, figure 6).
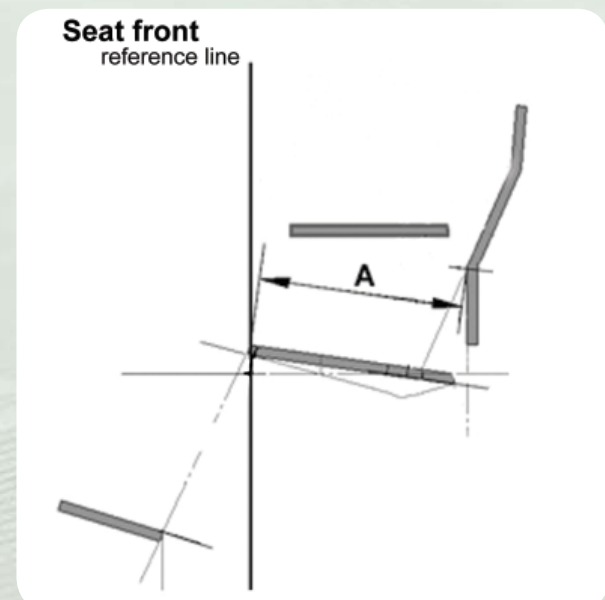

Figure 6: Measuring the depth of the seat

The width of the seat

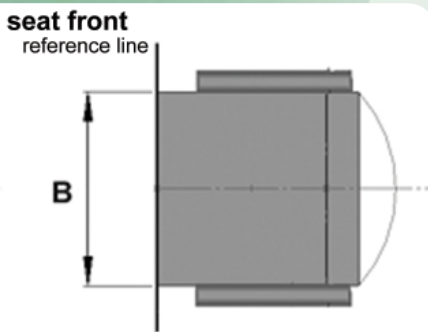This is the functional width that is available for the hips (B, figure 7).

Figure 7: Measuring the width of the seat

The width of the seat cushion

This is the physical width of the seat cushion.

Figure 8: Measuring the width of the seat cushion

The height of the lowest point of the small of the back in relation to the seat under load

This is the distance from the foremost point of the backrest that is considered to support the lowest point of the lumbar spinal column, to the seat when under load.

Height of the armrest in relation to the seat under load

This is the distance from the top surface of the armrest to the seat when it is under load.

The distance from the point of intersection of the backrest with the seat to the front edge of the seat

Lay a batten (approx.45 cm) along the lumbar-thoracic section of the backrest pressing it evenly against the surface. Allow the batten to touch the seat and measure from this point to the front edge of the seat. This is the distance required.
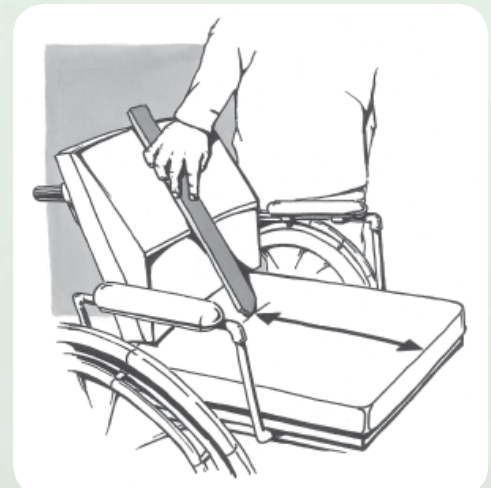

Figure 9: Measuring from the point where the backrest inclination would intersect the seat to the front edge of the seat

Seating height

The seating height is the distance from the top front edge of the seat to the back of the footrest. This can be measured with a steel tape measure.

Figure 10: Measuring the sitting height

3. Definitions and methods for measuring pressure distribution

Relevant index ciphers in the SMS analysis software

An important index cipher that is measured and then shown by the SMS analysis software is the pressure distribution: PD. This index cipher can be best explained by the following example:

> **Example**
> Take a person weighing 75 kg: their sitting force will be approximately 600 N. This is the load that the cushion will bring to bear on the buttocks. Suppose that the small areas directly around the tuberosities absorb 200 N of that load, then that means that the rest of the buttocks absorb 400 N. That is 400/600*100= 66% of the total load. The PD is 66.
> Suppose now that, after intervention, those same small areas around the tuberosities absorb 150 N then the rest will absorb 450 N. That is 450/600*100= 75% of the total load. The PD is now 75.
> This example shows that the higher the percentage is, the lower the load on the tuberosities and the better pressure distribution: precisely what was intended! In this way, the quality of the pressure distribution can be expressed on a scale from 1 to 100.

As well as the index ciphers for pressure distribution, PD, PD left and PD right, some other index ciphers are calculated with which it is possible to analyse and even explain the magnitude of the PD:

• Sitting force: total in Newtons;

• Distribution of sitting force: right and left in percentages, for example 45 – 55 %.

Often the sitting force is not equal to the sitting weight. This depends on the way in which the pressure sensors are activated. At the sides of the cushion, the sensors are not all activated vertically. This usually gives a result that is higher than the actual pressure. This increase has no influence on the determination of the PD. For this reason, the distribution of the sitting force is given as a percentage as this is the most relevant representation;

• Area under load: total in cm²;

• Distribution of area under load: right and left as percentages

• Relative position of the pelvis: in degrees

With the SMS analysis software it is also possible to locate the trochanters if they give a certain minimal increase in pressure in the overall picture.
If this is the case, it is possible to calculate the relative position of the pelvis if one makes an assumption for the height between the tuberosity and the trochanter in the algorithm.
The position of the pelvis is an experimental index cipher. It is a relative magnitude and intended exclusively for individual comparisons between various postures or measurements;

• PD coccyx

On the basis of the determined positions of the tuberosities, the position with the highest pressure value is sought in the anal cleft. It is assumed that this is the position of the coccyx. The pressure on the coccyx is represented by PD coccyx.

The same algorithm is used to calculate PD coccyx as for calculating PB tuberosity. The difference is that the calculated pressure on the coccyx is then increased by a certain percentage to obtain a PD coccyx index cipher of realistic magnitude; it is, after all, a sort of report assessment.
The coccyx is literally skin over bone which means the load acting upon it is far more critical, and that needs to be shown clearly in the report assessment;

• Deviation in position of the tuberosities: in degrees.

More information

If you have any questions or comments, or if you would like to see a demonstration of the SMS seating advice: go to our website www.pr-sella.nl!

For extensive work on sitting and pressure distribution, see the following books:

Staarink, H.A.M. *Zo zit het! Over zitten, stoelen en rolstoelen*,* Assen: Van Gorcum. 2007

Asbeck, F.W.A. van (red.). *Handboek dwarslaesie revalidatie,* paragraaf 18.1.1: Biomechanische en (neuro)fysiologische achtergronden van het zitten, tweede herziene druk, Houten: Bohn Stafleu Van Loghum. 2007

*'All there is to know about sitting, sitting behaviour, seats and wheelchairs'.
This English translation is in preperation.