INTERNATIONAL STANDARD

ISO 16840-1

First edition
2006-03-15

Wheelchair seating —

Part 1: Vocabulary, reference axis convention and measures for body segments, posture and postural support surfaces

Sièges de fauteuils roulants —

Partie 1: Vocabulaire, convention des axes de référence et mesures des segments corporels, des surfaces de posture et du siège

Reference number
ISO 16840-1:2006(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16840-1 was prepared by Technical Committee ISO/TC 173, *Assistive products for persons with disability*, Subcommittee SC 1, *Wheelchairs*.

ISO 16840 consists of the following parts, under the general title *Wheelchair seating*:

— *Part 1: Vocabulary, reference axis convention and measures for body segments, posture and postural support surfaces*

— *Part 2: Determination of physical and mechanical characteristics of devices intended to manage tissue integrity — Seat cushions*

— *Part 3: Determination of static, impact and repetitive load strengths for postural support devices*

The following parts are under preparation:

— *Part 4: Seating systems for use in motor vehicles*

— *Part 5: Determination of pressure relief characteristics of seat cushions intended to manage tissue integrity*

Introduction

The development of wheelchair seating as a sub-specialty of rehabilitation services has been occurring over the last several decades. This practice involves the selection and provision of wheelchair seating products that provide improved body support, movement control, and injury prevention for the wheelchair user. Inherent in this selection process is the measurement and communication of the anthropometrics and postural measures of the seated person, as well as the orientation, location and linear measures of the person's seating support surfaces.

However, there has been tremendous variation in the use of the terminology and definitions related to the clinical measures of a seated individual. Standard definitions and terms are lacking for communicating critical postural information and support surface parameters in a way that is uniformly useful to service providers, researchers, manufacturers, wheelchair users and purchasers when selecting and providing wheelchair seating devices.

The purpose of this part of 16840 is to specify standardised geometric terms and definitions for describing and quantifying a person’s anthropometric measures and seated posture, as well as the spatial orientation and dimensions of a person’s seating support surfaces. This also allows for the systematic monitoring of a person's seated posture change over time.

Wheelchair seating —

Part 1:
Vocabulary, reference axis convention and measures for body segments, posture and postural support surfaces

1 Scope

This part of ISO 16840 applies to seating intended to provide postural support within a wheelchair. It specifies:

a) a global coordinate system that permits the determination and recording of a person's posture while seated in a wheelchair;

b) the standard terms and definitions for use in describing both the posture and the anthropometrics of a person seated in a wheelchair;

c) the terms and definitions for describing the dimensions, location and orientation of seating support surfaces, which together comprise the body support system.

This part of ISO 16840 does not specify any methods for use in measuring a person's seated posture, nor does it define terms for dynamic physiological movements (such as flexion or extension).

This part of 16840 might be applicable to seating other than that intended to be used within a wheelchair.

2 General terms and definitions

2.1
absolute angle
angle which represents the orientation in space of a body segment or support surface reference plane relative to the gravitational axis system

NOTE See 5.2.

2.2
body centreline
vertical line falling on the midsagittal plane of the body, as viewed in the frontal plane

2.3
body segment line
line defined by two designated body landmarks, either palpated or calculated, used in determining angular positions of body segments

2.4
contact surface
surface of the seating support in contact with the seated person's body

2.5
depth
linear dimension of a seating support surface measured in the Y direction on a line parallel to the support surface reference plane

See Figure 1.

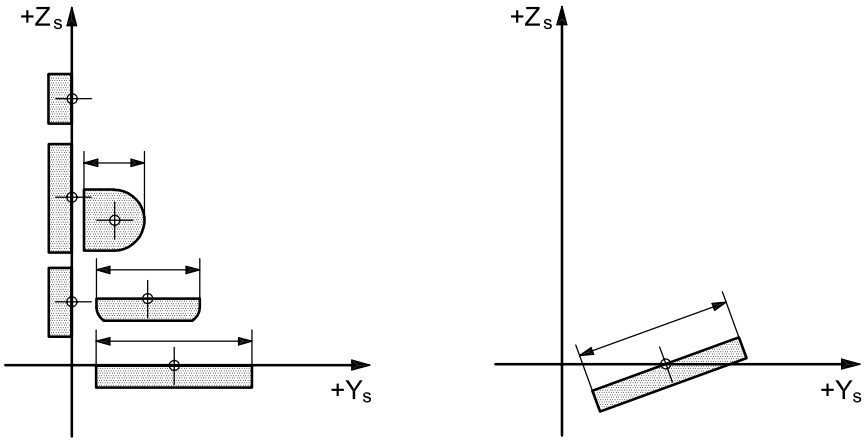


Figure 1 — Examples of depth

2.6
length
linear dimension of a seating support surface measured in the Z direction on a line parallel to the support surface reference plane

See Figure 2.

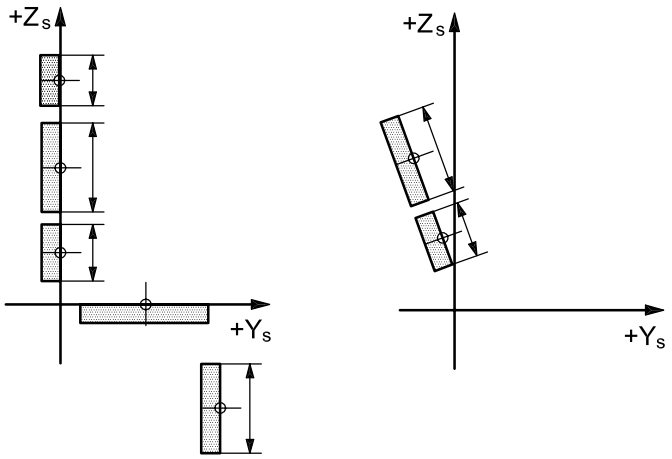


Figure 2 — Examples of length

2.7
reference position
fixed hypothetical baseline position to which other positions may be referenced

2.8
relative angle
angle formed between two body segment lines or two support surface reference lines

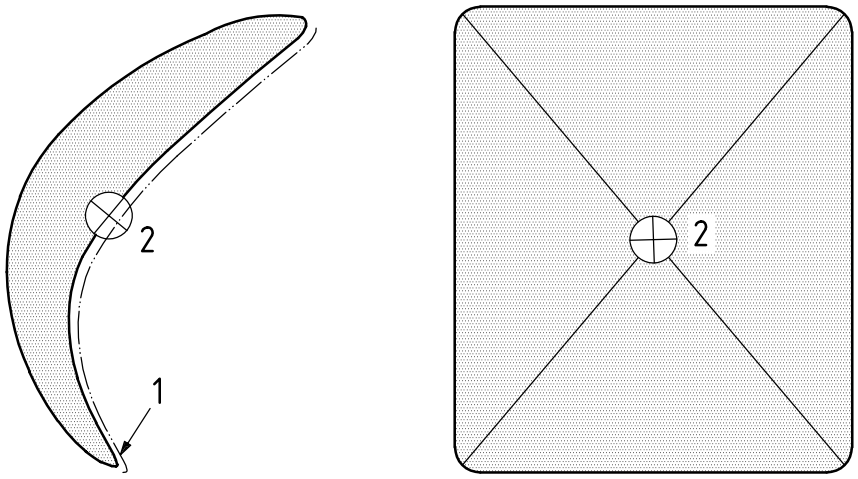
2.9
seated anatomical axis system
SAAS
axis system used to define the orientation of the body segments in space and to each other

2.10
seated reference position
SRP
orthogonal seated position to which other positions may be referenced

2.11
support surface axis system
SSAS
axis system used to define the orientation, location and linear dimensions of seating support surfaces

2.12
support surface geometric centre
SSGC
point of intersection of two or more lines joining the furthest points from the edges of a contact surface, measured along the surface

See Figure 3.



a) Asymmetric contoured surface **b) Planar surface**

Key
1 line along the contoured surface
2 support surface geometric centre (SSGC)

Figure 3 — Illustration of the SSGC on curved and planar support surfaces

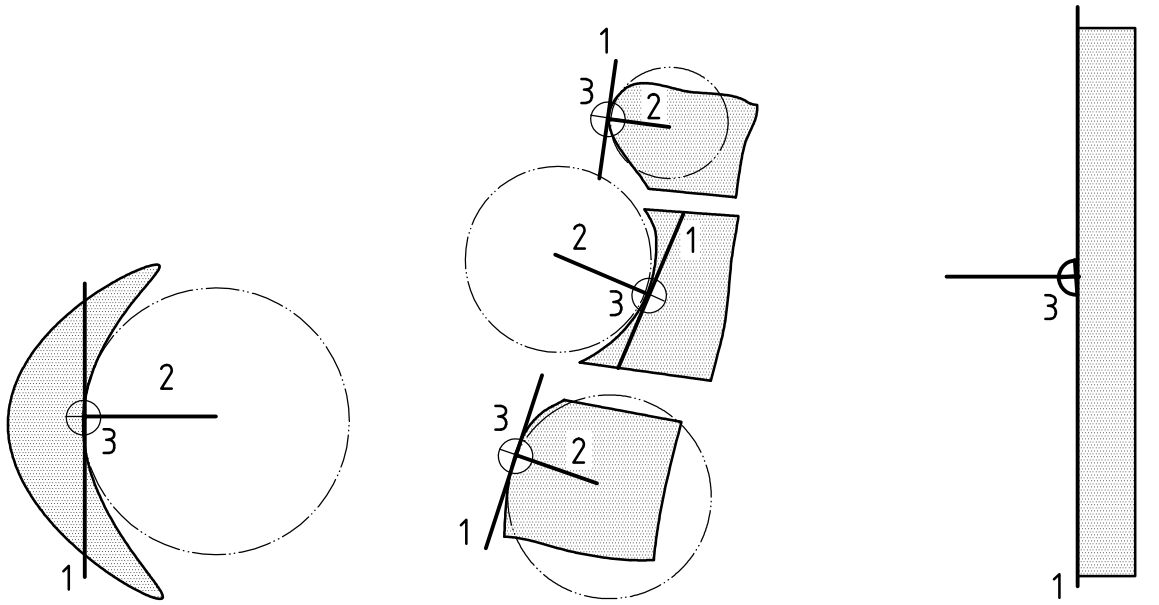
2.13
support surface reference line
designated line passing through the support surface geometric centre used in measurement of the absolute and relative angles of the seating support surface

2.14
support surface reference position
SSRP
fixed hypothetical baseline position of support surfaces in the three orthogonal planes to which other positions may be referenced

2.15
support surface reference plane
plane passing through the SSGC tangential to the surface curvature at the SSGC radius at the point of the SSGC

See Figure 4.

NOTE The tangent to the radius of a planar surface is parallel to the surface.



a) Symmetrical contoured support surface **b) Asymmetrical contoured support surfaces** **c) Planar surface**

Key
1 support surface reference plane
2 radius of the support surface curve at the SSGC
3 SSGC

Figure 4 — Examples of support surface reference planes for contoured and planar surfaces

2.16
thickness
linear dimension of a seating support surface measured perpendicular to the support surface reference plane

See Figure 5.

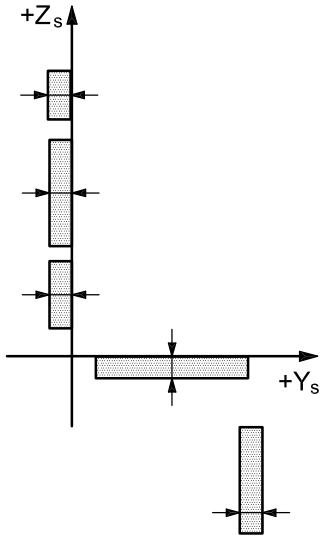


Figure 5 — Examples of thickness

2.17
wheelchair axis system
WAS
axis system which may be used to define the orientation and location of the person and any items attached to or contained within a wheelchair base relative to that base

2.18
width
linear dimension of a seating support surface measured in the X direction on a line parallel to the support surface reference plane

See Figure 6.

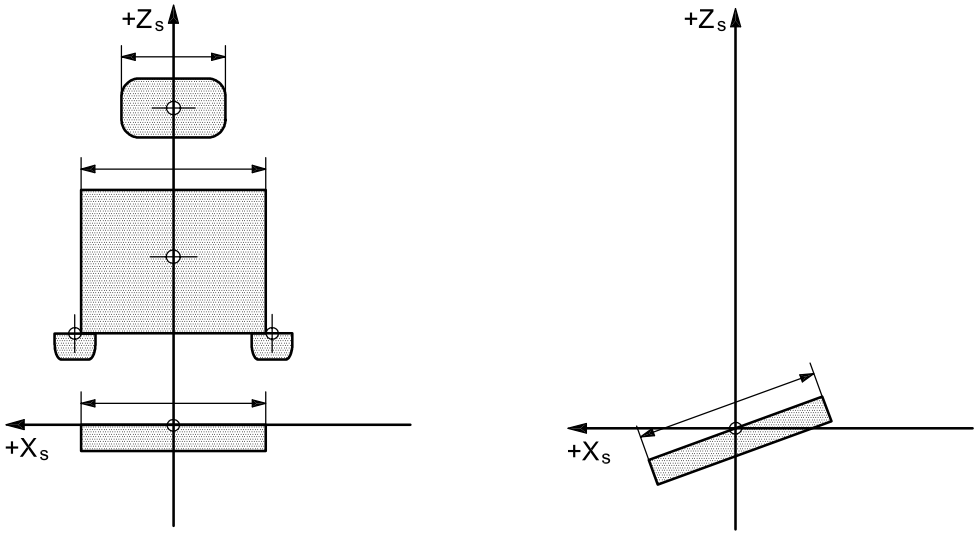


Figure 6 — Examples of width

3 Abbreviated terms and subscripts

3.1 Abbreviated terms

AS anterior support

ASIS anterior superior iliac spine

IS inferior support

LS lateral support

MS medial support

PS posterior support

PSIS posterior superior iliac spine

SAAS seated anatomical axis system

SSAS support surface axis system

SRP seated reference position

SSGC support surface geometric centre

SSRP support surface reference position

WAS wheelchair axis system

3.2 Subscripts

d depth

ed effective depth

el effective length

ew effective width

fang frontal angle

floc frontal location

L left

l length

R right

sang sagittal angle

sloc sagittal location

t thickness

tang transverse angle

tloc transverse location

w width

4 Global coordinate system principles

4.1 General

This part of 16840 is based on a three-dimensional global coordinate system applied separately to the wheelchair, the seating support surfaces and the wheelchair user. Separately and/or collectively this coordinate system allows for measurement in the three traditional orthogonal planes of locations, linear measures, and angles of the body segments of a person and the seating support surfaces.

The measures of a person (either linear or angular) will not necessarily be identical to those of the seating support surfaces. The prescription of a seating support surface should be determined through clinical interpretation or translation of the measures of a person into those appropriate for support surfaces that will adequately support a person in a desired posture.

4.2 Structure

Clause 5 specifies the integrated geometric reference system upon which all the following definitions for this part of ISO 16840 are based. Next, the measurement definitions for seating support surfaces, and the body measures are specified. They are each defined using the three orthogonal planes, sagittal, frontal and transverse. For each plane, a standard reference position (SSRP or SRP), and definitions for measures of support surface locations, linear dimensions, absolute angles and relative angles (where appropriate) are specified.

5 Terms and definitions of an integrated geometric reference system

5.1 General

The following are terms and definitions for an integrated geometric reference system that permits the measurement of a person's seated posture. The measured seated posture can then be recorded relative to the person's seating support surfaces, and finally, in relation to the global reference (the wheelchair frame) in which the person is seated.

Five interrelated components comprise the integrated geometric reference system:

a) the wheelchair axis system (WAS) defines a fixed global reference system, specified by the geometry of each person's wheelchair after configuration of that wheelchair for the specific person;

b) the support surface axis system (SSAS) defines the coordinate conventions used to specify the support surface reference position;

c) the support surface reference position (SSRP) defines a fixed hypothetical position of the support surfaces to which other positions may be referenced;

d) the seated anatomical axis system (SAAS) defines the geometric measures used to specify and record the positions of a person's body segments relative to the seated reference position;

e) the seated reference position (SRP) defines a fixed hypothetical position of the seated person to which other positions may be referenced.

The integration and application of these interrelated geometric systems allow the systematic measurement and recording of a person's wheelchair-seated posture. Subsequent measurements will allow the systematic monitoring of seated posture change over time.

Of fundamental importance are the selection and consistent use of an axis system. This convention, termed the global coordinate system, then allows the systematic integration of the above measurements.

For all measurements, when a line or coordinate position does not fall on one of the three defined orthogonal planes, the line or coordinate position is projected to the appropriate plane and then measurements are taken.

NOTE This simplification reduces all three-dimensional measures to two measurements, which is consistent with current clinical practice.

5.2 Global coordinate system

5.2.1 Basis

The global coordinate system is based on a gravitational axis system in which the +Z axis has been designated as the upward vertical axis. Both X and Y axes are at right angles to Z and to each other. The location of the origin for the global coordinate system is described in 5.3.

5.2.2 Direction of axes

The right-hand directional rule is used to define the directions of the coordinate axes, specifically, thumb vertical along the positive (+) Z axis, index finger defines the positive (+) X axis, and the middle finger defines the positive (+) Y axis

See Figure 7.

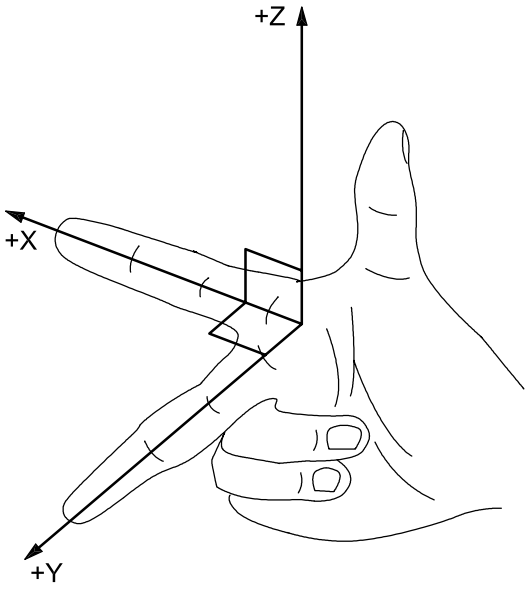
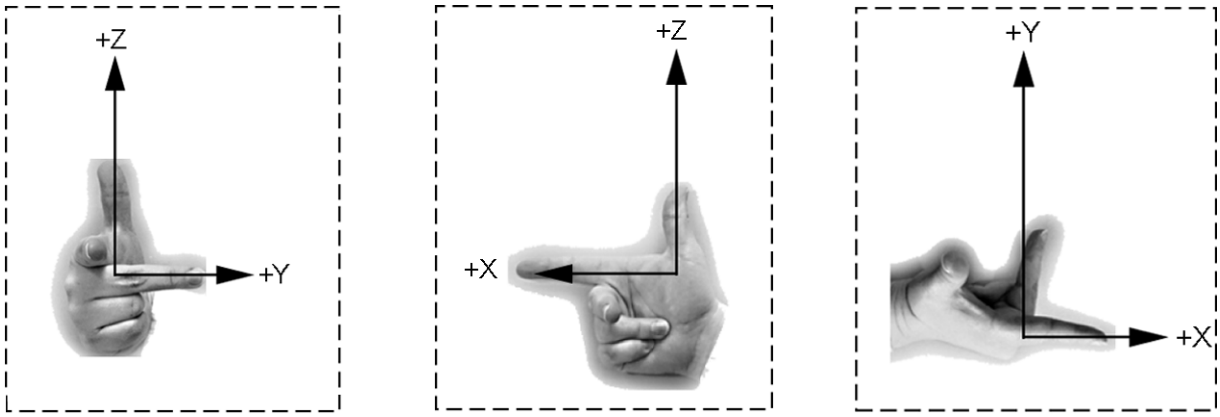


Figure 7 — Right-hand directional rule defines positive directions of axes X, Y and Z

5.2.3 Orthogonal planes

The three axes, X, Y, and Z, create three orthogonal planes, YZ (sagittal), ZX (frontal), and XY (transverse), illustrated in Figure 8.



a) Sagittal (YZ) plane **b Frontal (ZX) plane** **c) Transverse (XY) plane**

Figure 8 — Three axes and created orthogonal planes

5.2.4 360° measurement convention

A 360° measurement notation is used throughout the integrated measurement system. This system specifies that all angular measures start at the positive Z axis (or positive Y axis in the transverse view) and proceed to 360° in a clockwise direction according to the left-hand screw rule

See Figure 9.

NOTE There are no negative angles with the 360° notation.

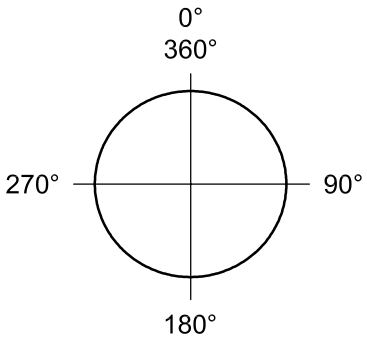
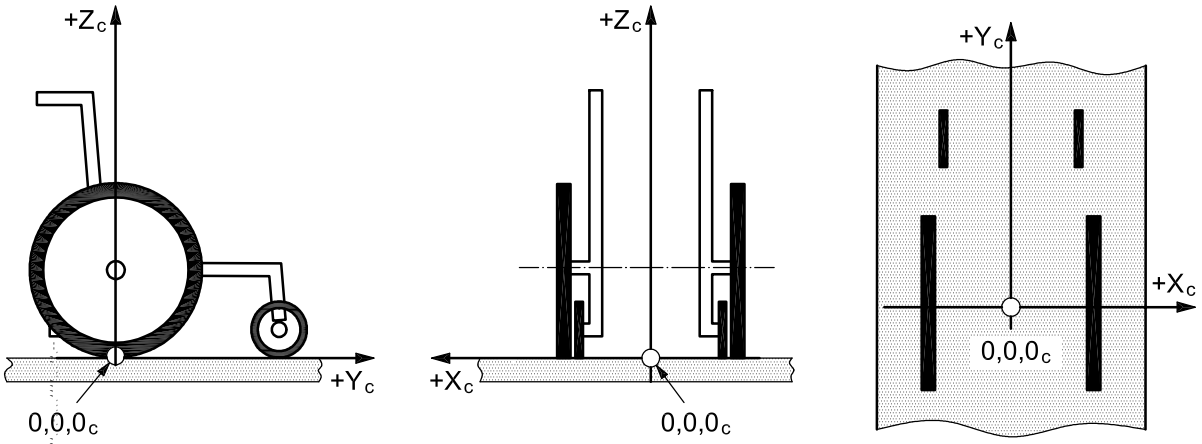


Figure 9 — 360° measurement notation system

5.3 Wheelchair axis system (WAS)

The WAS serves as the global reference system based on the axis convention defined in 5.2, and denoted with a subscript “c”. It establishes the absolute (global) reference origin ($0,0,0_c$) for the global coordinate system.

The global origin ($0,0,0_c$) is located on the floor directly below the midpoint of a line passing through the axles of the rear-most pair of non-castored wheels, or drive wheels, on the wheelchair frame (see Figure 10). In the case of an adjustable rear axle or drive wheel axle, the location of the axle should be configured as desired for the user and this location should be disclosed and established as the $0,0,0_c$ origin. In any case, where the above description cannot be applied, the $0,0,0_c$ point shall be ascribed and specified.



a) Side view (sagittal) **b) Front view (frontal)** **c) Top view (transverse)**

Figure 10 — Location of global origin as defined by the wheelchair frame geometry

5.4 Support surface axis system (SSAS)

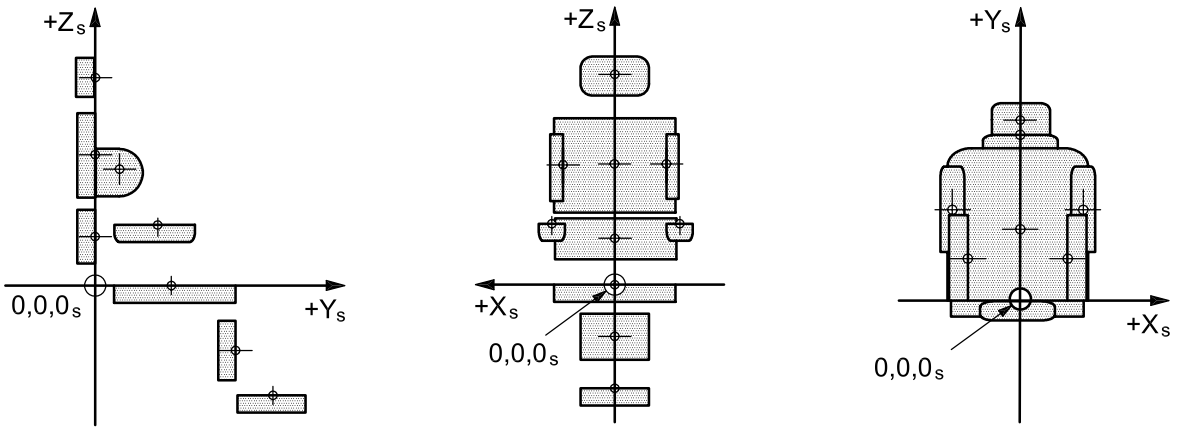
5.4.1 General

The SSAS is a geometric axis system based on the axis convention defined in 5.2, but denoted with a subscript “s”. The SSAS is used to specify the orientation, coordinate locations and linear dimensions, of seating support surfaces in the three orthogonal planes.

5.4.2 Location of the SSAS origin

The SSAS origin ($0,0,0_s$) is the point at which a line, passing through the SSGC and parallel to the reference plane of the rearmost seat support surface intersects the reference plane of the lowest back support surface.

See Figure 11.



a) Side view (sagittal) **b) Front view (frontal)** **c) Top view (transverse)**

Figure 11 — Support surface axis system

5.4.3 Coordinate locations of support surfaces

The coordinate locations of support surfaces are defined by values along the two axes in each orthogonal plane. These locations are measured between the $0,0,0_s$ origin and the support surface geometric centres of each support surface. For each support surface in Figure 11, the support surface geometric centres (SSGC) are shown.

5.4.4 Orientation of individual support surfaces

The absolute angle of a support surface is measured about an axis passing through the SSGC. When specifying the absolute angle of a support surface in any of the orthogonal planes, a reference line, lying along the plane of the support surface of interest, is extended from the support surface geometric centre. As specified in Annex A, this reference line extends in a direction which allows measurement of the support surface angle so that it can be correlated with the absolute angle of the body segment it supports. Figures 16, 21 and 24 illustrate absolute angle measures of selected support surfaces in the three planes.

5.5 Seated anatomical axis system (SAAS)

The SAAS is a geometric axis system based on the axis convention defined in 5.2 but denoted with a subscript “p” The SAAS is used to specify linear body measures, and orientation in space of a person's body segments in the three orthogonal planes.

5.5.1 Location of the SAAS origin

The SAAS origin ($0,0,0_p$) is the point at which the Z axis crosses the midpoint of a line joining the right and left hip joint centres.

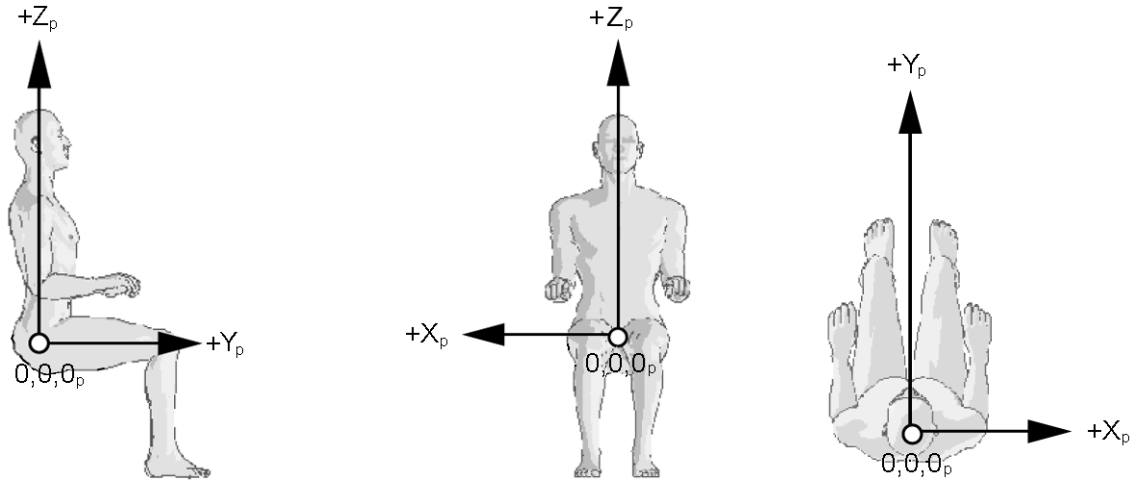
See Figure 12.

5.5.2 Body segments

Lines joining anatomical landmarks and/or computed joint centres define the body segments of postural interest. Tables 1 (7.2.1), 4 (7.3.1) and 6 (7.4.1) define the anatomical landmarks, body segments and segment lines in each of the three planes. The spatial orientation of the body segments relative to the axis system defines the person's seated posture. Deviations of body segment lines from the designated reference axis, projected to the three orthogonal planes, permit the measurement of absolute body segment angles.

5.5.3 Orientation of body segments

The origin for the axis system may be transposed to various defined locations on the body, usually joint centres, thereby allowing measurements of body segment orientations relative to the reference axis (absolute angles), or to each other (relative angles). The absolute angle of a body segment is measured about an axis passing through the anatomical centre of rotation of that segment. Tables 2 (7.2.2), 5 (7.3.2) and 7 (7.4.2) specify the points of rotation for each body segment in each plane.



a) Side view (sagittal) b) Front view (frontal) c) Top view (transverse)

Figure 12 — Seated anatomical axis system

6 Terms and definitions of support surface measures

6.1 General

6.1.1 Generic support surfaces with abbreviations

Definitions in this clause permit the quantification of the location, linear measures, and spatial orientation of a seated person's support surfaces in the sagittal, frontal and transverse planes.

Generic support surfaces with abbreviations are used to represent various types of commonly used actual support surfaces. All support surface designations refer to the part of the support surface in contact with the person's body when in a seated position.

— PS indicates a generic support surface in contact with a posterior surface of the body.

— AS indicates a generic support surface in contact with the anterior surface of the body.

— LS indicates a generic support surface in contact with a lateral surface of the body.

— MS indicates a generic support surface in contact with a medial surface of the body.

— SS indicates a generic support surface in contact with a superior surface of the body.

— IS indicates a generic support surface in contact with an inferior surface of the body.

6.1.2 Coordinate locations of support surfaces

The axis system for defining the location of each support surface is specified in 5.4. Locations in each view are defined by two coordinates (X,Y; Z,X; or Y,Z) measured from the $0,0,0_s$ origin of the support surface axis system (SSAS) to the support surface geometric centre (SSGC) of the support surface of interest.

NOTE The conventional medical terms inferior-superior indicate locations in the positive or negative Z direction; the terms anterior-posterior indicate locations in the positive or negative Y direction; and the terms lateral-medial indicate locations in the positive or negative X direction from the $0,0,0_s$ origin.

6.1.3 Absolute and relative angles of support surfaces

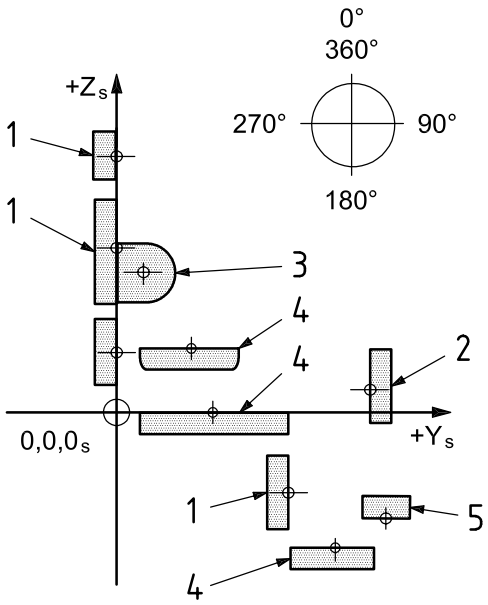
Absolute angular orientations of seating support surfaces are values measured in accordance with the 360° measurement convention. Tables A.1, A.2, and A.3 in Annex A define the axial orientation of the reference lines for typical support surfaces in the SSRP in each of the three orthogonal planes. The direction of extension of the reference line has been defined in such a manner that the angular measure of the support surface correlates to the angular measure of the body segment being supported. Absolute angle measurement definitions are provided for all three orthogonal planes. Relative angle definitions are provided for the sagittal plane only since relative angles in the other two planes are rarely used in practice.

6.1.4 Linear measures of support surfaces

To differentiate between overall dimensions and intended contact surface dimensions, the word “effective” is added to a term to indicate that the dimension describes the intended contact surface of the support surface. The subscripts “l”, “w”, “d” and “t” are used to indicate length, width, depth and thickness, respectively. The subscripts “el”, “ew”, and “ed” are used to indicate effective length, effective width and effective depth.

6.2 Terms and definitions of support surface measures in the sagittal view

6.2.1 Support surface reference position in the sagittal plane



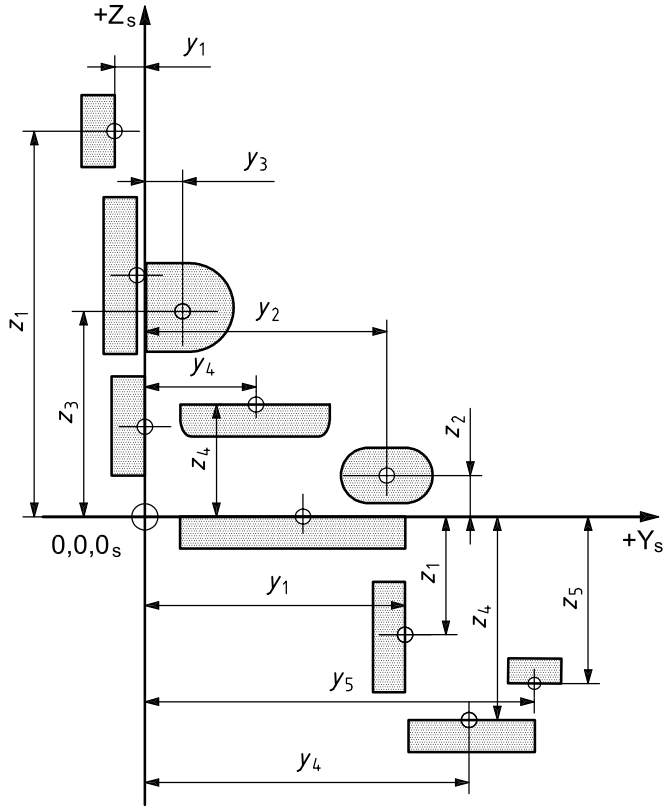
Key

1 posterior support (PS)
2 anterior support (AS)
3 lateral support (LS)
4 inferior support (IS)
5 superior support (SS)

Figure 13 — Sagittal view of generic support surfaces in the SSRP

6.2.2 Coordinate locations of support surfaces in the sagittal view

The sagittal location of a seating support surface is defined by the Z and Y coordinates of the SSGC relative to the $0,0,0_S$ origin. Figure 14 and 6.2.2.1 to 6.2.2.6 define location measures of commonly used support surfaces in the sagittal view.



Key

y_1, z_1	posterior support sagittal location (PS_{sloc})
y_2, z_2	anterior support sagittal location (AS_{sloc})
y_3, z_3	lateral support sagittal location (LS_{sloc})
y_4, z_4	inferior support sagittal location (IS_{sloc})
y_5, z_5	superior support sagittal location (SS_{sloc})

Figure 14 — Coordinate locations of support surfaces in the sagittal view

6.2.2.1
posterior support sagittal location
PS_{sloc}
Y and Z distances from the SSAS origin to the support surface geometric centre of the posterior support

See y_1 and z_2 in Figure 14.

6.2.2.2
anterior support sagittal location
AS_{sloc}
Y and Z distances from the SSAS origin to the support surface geometric centre of the anterior support

See y_2 and z_2 in Figure 14.

6.2.2.3
lateral support sagittal location
LS_{sloc}
Y and Z distances from the SSAS origin to the support surface geometric centre of the lateral support

See y_3 and z_3 in Figure 14.

6.2.2.4
medial support sagittal location
MS_{sloc}
Y and Z distances from the SSAS origin to the support surface geometric centre of the medial support

6.2.2.5
inferior support sagittal location
IS_{sloc}
Y and Z distances from the SSAS origin to the support surface geometric centre of the inferior support

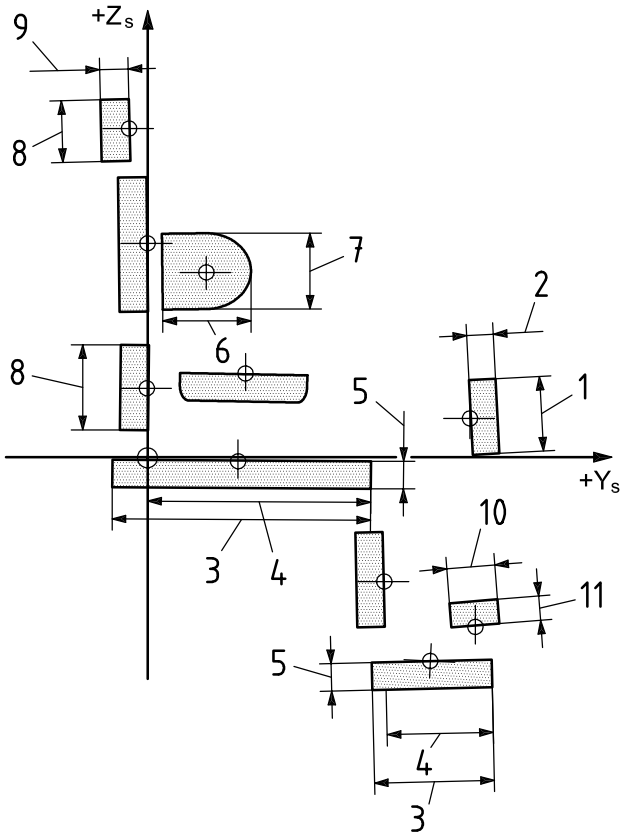
See y_4 and z_4 in Figure 14.

6.2.2.6
superior support sagittal location
SS_{sloc}
Y and Z distances from the SSAS origin to the support surface geometric centre of the superior support

See y_5 and z_5 in Figure 14.

6.2.3 Linear measures of support surfaces in the sagittal view

All terms defined in this subclause are for the overall dimensions of a seating support surface, as viewed in the sagittal plane, unless noted otherwise. Figure 15 and 6.2.3.1 to 6.2.3.13 define linear measures of generic support surfaces, measured in the sagittal view.



Key

1	anterior support length (AS_l)	5	inferior support thickness (IS_t)	9	posterior support thickness (PS_t)
2	anterior support thickness (AS_t)	6	lateral support depth (LS_d)	10	superior support depth (SS_d)
3	inferior support depth (IS_d)	7	lateral support length (LS_l)	11	superior support thickness (SS_t)
4	inferior support effective depth (IS_{ed})	8	posterior support length (PS_l)		

Figure 15 — Linear measures of generic support surfaces in the sagittal view

6.2.3.1
anterior support length
AS_l
distance from the upper-most to the lower-most surfaces measured parallel to the AS support surface reference plane

See item 1 in Figure 15.

6.2.3.2
anterior support thickness
AS_t
distance from the front to the back of the AS measured perpendicular to the AS support surface reference plane

See item 2 in Figure 15.

6.2.3.3
inferior support depth
IS_d
distance from front to the back of the inferior support measured parallel to the IS support surface reference plane

See item 3 in Figure 15.

6.2.3.4
inferior support effective depth
IS_{ed}
distance from front of the inferior support to the intersection of the posterior and inferior support surface reference planes measured parallel to the IS support surface reference plane

See item 4 in Figure 15.

6.2.3.5
inferior support thickness
IS_t
distance from the top to the bottom of the IS measured perpendicular to the IS support surface reference plane

See item 5 in Figure 15.

6.2.3.6
lateral support depth
LS_d
distance from front to the back of the lateral support measured parallel to the LS support surface reference plane

See item 6 in Figure 15.

6.2.3.7
lateral support length
LS_l
distance from the upper-most to the lower-most surfaces measured parallel to the LS support surface reference plane

See item 7 in Figure 15.

6.2.3.8
medial support depth
MS_d
distance from front to the back of the medial support measured parallel to the MS support surface reference plane

NOTE Not shown in Figure 15.

6.2.3.9
medial support length
MS_l
distance from the upper-most to the lower-most surfaces measured parallel to the MS support surface reference plane

NOTE Not shown in Figure 15.

6.2.3.10
posterior support length
PS_l
distance from the upper-most to the lower-most surfaces measured parallel to the PS support surface reference plane

See item 8 in Figure 15.

6.2.3.11
posterior support thickness
PS_t
distance from the front to the back of the PS measured perpendicular to the PS support surface reference plane

See item 9 in Figure 15.

6.2.3.12
superior support depth
SS_d
distance from front to the back of the superior support measured parallel to the SS support surface reference plane

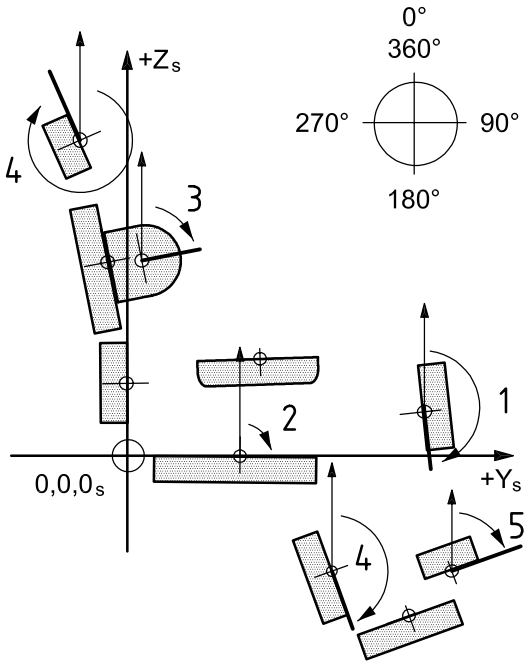
See item 10 in Figure 15.

6.2.3.13
superior support thickness
SS_t
distance from the top to the bottom of the SS measured perpendicular to the SS support surface reference plane

See item 11 in Figure 15.

6.2.4 Absolute angles of generic support surfaces in the sagittal view

The angular position of a seating support surface in the sagittal view is defined as the angle between the vertical +Z axis and the support surface reference line, as viewed from the right side of the seat and measured in a clockwise direction using the 360° notation. When support surfaces have right and left members, the left side is measured as if viewed from the right for consistency of values. Figure 16 and 6.2.4.1 to 6.2.4.6 define the absolute angles of generic support surfaces viewed in the sagittal plane. A.2.1 defines the axial orientation of reference lines for use in taking absolute angle measures in the sagittal plane.



Key

1 anterior support sagittal angle (AS_{sang})
2 inferior support sagittal angle (IS_{sang})
3 lateral support sagittal angle (LS_{sang})
4 posterior support sagittal angle (PS_{sang})
5 superior support sagittal angle (SS_{sang})

Figure 16 — Examples of absolute angles of generic support surfaces in the sagittal view

6.2.4.1
anterior support sagittal angle
AS_{sang}
angle in the YZ plane between the Z axis and the AS reference line for the relevant anterior support surface, as specified in Annex A

See item 1 in Figure 16.

6.2.4.2
inferior support sagittal angle
IS_{sang}
angle in the YZ plane between the Z axis and the IS reference line for the relevant inferior support surface, as specified in Annex A

See item 2 in Figure 16.

6.2.4.3
lateral support sagittal angle
LS_{sang}
Angle in the YZ plane between the Z axis and the LS reference line for the relevant lateral support surface, as specified in Annex A

See item 3 in Figure 16.

6.2.4.4
medial support sagittal angle
MS_{sang}
angle in the YZ plane between Z axis and the MS reference line for the relevant medial support surface, as specified in Annex A

NOTE Not shown in Figure 16.

6.2.4.5
posterior support sagittal angle
PS_{sang}
angle in the YZ plane between Z axis and the PS reference line for the relevant posterior support surface, as specified in Annex A

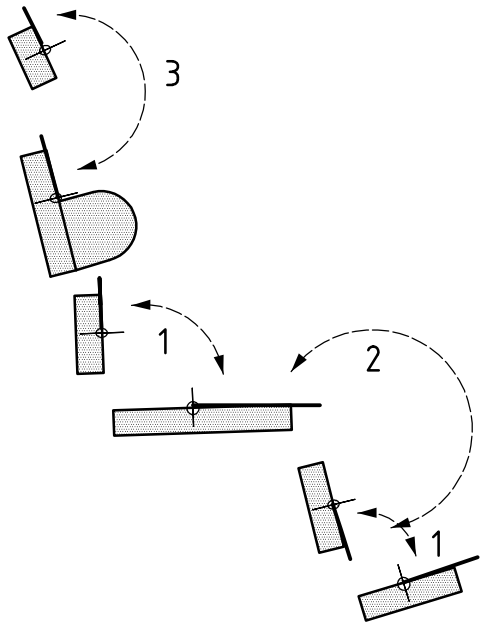
See item 4 in Figure 16.

6.2.4.6
superior support sagittal angle
SS_{sang}
angle in the YZ plane between Z axis and the SS reference line for the relevant superior support surface, as specified in Annex A

See item 5 in Figure 16.

6.2.5 Relative angles of generic support surfaces in the sagittal plane

Relative angles for only the sagittal plane have been defined below, as deviations in these relative angles are more commonly used and have a profound effect on seated posture. Relative angles of support surfaces in the sagittal plane are defined as the angle formed between two adjacent support surfaces, measured on the anterior/superior side of the relevant surfaces. Relative angles may be obtained by direct measurement or by calculation from the absolute angles. Figure 17 and 6.2.5.1 to 6.2.5.3 define three generic relative angles commonly used in wheelchair seating.



Key
1 posterior support to inferior support sagittal angle $(PS\text{-}IS)_{sang}$
2 inferior support to posterior support sagittal angle $(IS\text{-}PS)_{sang}$
3 posterior support to posterior support sagittal angle $(PS\text{-}PS)_{sang}$

Figure 17 — Examples of relative angles of generic support surfaces in the sagittal plane

6.2.5.1
posterior support to inferior support relative sagittal angle
$(PS\text{-}IS)_{sang}$
angle between the PS and the IS reference lines

See item 1 in Figure 17.

EXAMPLE Back support to seat support angle.

6.2.5.2
inferior support to posterior support relative sagittal angle
$(IS\text{-}PS)_{sang}$
angle between IS and the PS reference lines

See item 2 in Figure 17.

EXAMPLE Seat support to calf support angle.

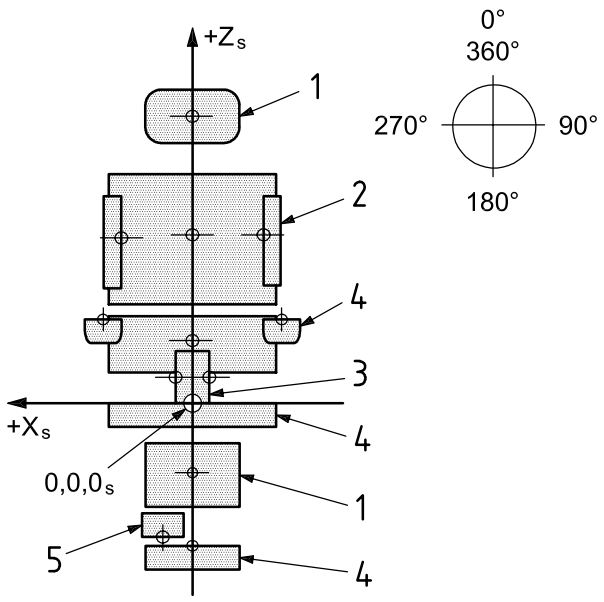
6.2.5.3
posterior support to posterior support relative sagittal angle
$(PS\text{-}PS)_{sang}$
angle between PS and PS reference lines

See item 3 in Figure 17.

EXAMPLE Head support to back support angle.

6.3 Terms and definitions of support surface measures in the frontal view

6.3.1 Support surface reference position in the frontal view



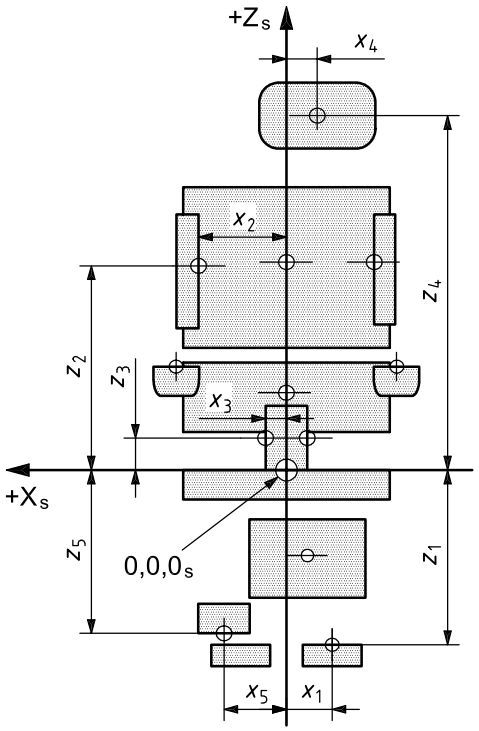
Key

1	posterior support (PS)	4	inferior support (IS)
2	lateral support (LS)	5	superior support (SS)
3	medial support (MS)		

Figure 18 — Frontal view of generic support surfaces in the SSRP

6.3.2 Coordinate locations of support surfaces in the frontal view

The frontal location of a seating support surface is defined by the X and Z coordinates of the SSGC relative to $0,0,0_S$ origin. Figure 19 and 6.3.2.1 to 6.3.2.6 define location measures of commonly used support surfaces viewed in the frontal plane.



Key

x_1, z_1	inferior support frontal location (IS_{floc})	x_4, z_4	posterior support frontal location (PS_{floc})
x_2, z_2	lateral support frontal location (LS_{floc})	x_5, z_5	superior support frontal location (SS_{floc})
x_3, z_3	medial support frontal location (MS_{floc})		

NOTE Surfaces shown in Figure 19 have been arbitrarily displaced from the SSRP for purposes of illustration.

Figure 19 — Coordinate locations of support surfaces in the frontal view

6.3.2.1
anterior support frontal location
AS_{floc}
x and z distances from the SSAS origin to the SSGC of the anterior support

NOTE Not shown in Figure 19.

6.3.2.2
inferior support frontal location
IS_{floc}
x and z distances from the SSAS origin to the SSGC of the inferior support

See x_1 and z_1 in Figure 19.

6.3.2.3
lateral support frontal location
LS_{floc}
x and z distances from the SSAS origin to the SSGC of the lateral support

See x_2 and z_2 in Figure 19.

6.3.2.4
medial support frontal location
MS_{floc}
x and z distances from the SSAS origin to the SSGC of the medial support

See x_3 and z_3 in Figure 19.

6.3.2.5
posterior support frontal location
PS_{floc}
x and z distances from the SSAS origin to the SSGC of the posterior support

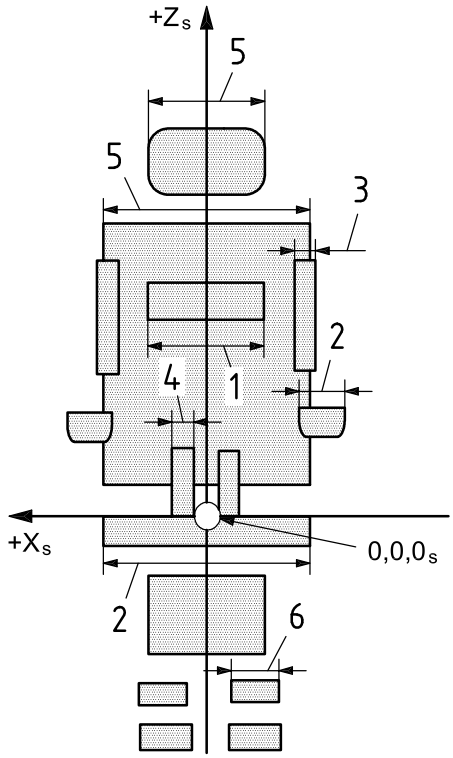
See x_4 and z_4 in Figure 19.

6.3.2.6
superior support frontal location
SS_{floc}
x and z distances from the SSAS origin to the SSGC of the superior support

See x_5 and z_5 in Figure 19.

6.3.3 Linear measures of support surfaces in the frontal view

All terms defined in this subclause are for the overall dimensions of a seating support surface, as viewed in the frontal plane, unless noted otherwise. Figure 20 and 6.3.3.1 to 6.3.3.6 define linear measures of generic support surfaces, measured in the frontal view.



Key

1	anterior support width (AS_w)	4	medial support thickness (MS_t)
2	inferior support width (IS_w)	5	posterior support width (PS_w)
3	lateral support thickness (LS_t)	6	superior support width (SS_w)

Figure 20 — Linear measures of generic support surfaces measured in the frontal view

6.3.3.1
anterior support width
AS_w
maximum distance between the outer surfaces of the AS, measured at its widest point and parallel to the support surface reference plane

See item 1 in Figure 20.

6.3.3.2
inferior support width
IS_w
maximum distance between the outer surfaces of the IS measured parallel to the IS reference plane

See item 2 in Figure 20.

6.3.3.3
lateral support thickness
LS_t
maximum distance between the outer surfaces of the LS measured perpendicular to the LS support surface reference plane

See item 3 in Figure 20.

6.3.3.4
medial support thickness
MS_t
maximum distance between the outer surfaces of the MS measured perpendicular to the MS support surface reference plane

See item 4 in Figure 20.

6.3.3.5
posterior support width
PS_w
maximum distance between the outer surfaces of the PS, measured at its widest point and parallel to the support surface reference plane

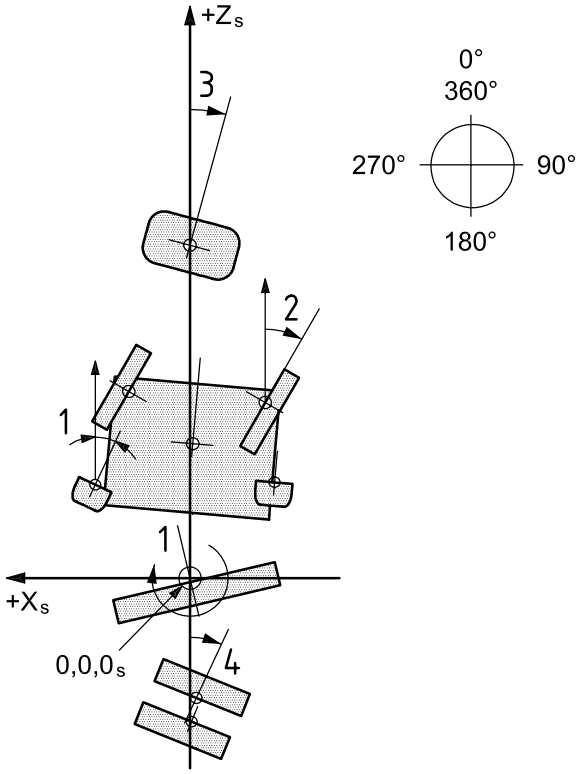
See item 5 in Figure 20.

6.3.3.6
superior support width
SS_w
maximum distance between the outer surfaces of the SS, measured at widest point and parallel to the SS reference plane

See item 6 in Figure 20.

6.3.4 Absolute angles of generic support surfaces in the frontal plane

The absolute angular position of a seating support surface in the frontal plane is defined as the angle between the vertical, +Z, axis and the support surface reference line measured in a clockwise direction using 360° notation. The support surface reference line, as specified in 6.4 extends from the SSGC in a manner that allows correlation between the support surface angle and the angle of the body segment being supported. See A.2.3 for details on specific support surfaces. Figure 21 and 6.3.4.1 to 6.3.4.6 define the absolute angles of generic support surfaces measured in the frontal plane.



Key

1	inferior support (IS_{fang})	3	posterior support frontal angle (PS_{fang})
2	lateral support frontal angle (LS_{fang})	4	superior support (SS_{fang})

NOTE Surfaces shown in Figure 21 have been arbitrarily displaced from the SSRP for purposes of illustration.

Figure 21 — Examples of absolute angle measures of generic support surfaces in the frontal view

6.3.4.1
anterior support frontal angle
AS_{fang}
angle in the ZX plane between the Z axis and the AS reference line for the relevant anterior support surface, as specified in Annex A

NOTE Not shown in Figure 21.

6.3.4.2
inferior support frontal angle
IS_{fang}
angle in the ZX plane between the Z axis and the IS reference line for the relevant inferior support surface, as specified in Annex A

See item 1 in Figure 21.

6.3.4.3
lateral support frontal angle
LS_{fang}
angle in the ZX plane between the Z axis and the LS reference line for the relevant lateral support surface, as specified in Annex A

See item 2 in Figure 21.

6.3.4.4
medial support frontal angle
MS_{fang}
angle in the ZX plane between the Z axis and the MS reference line for the relevant medial support surface, as specified in Annex A

NOTE Not shown in Figure 21.

6.3.4.5
posterior support frontal angle
PS_{fang}
angle in the ZX plane between the Z axis and the PS reference line for the relevant posterior support surface, as specified in Annex A

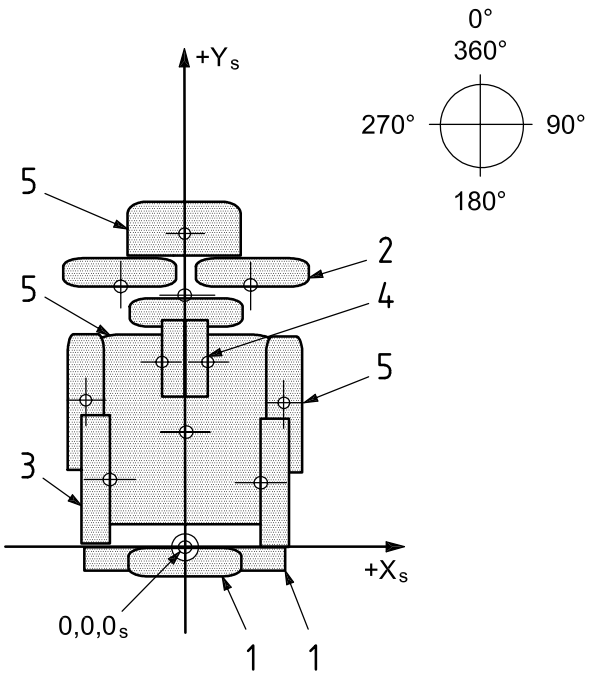
See item 3 in Figure 21.

6.3.4.6
superior support frontal angle
SS_{fang}
angle in the ZX plane between the Z axis and the SS reference line for the relevant superior support surface, as specified in Annex A

See item 4 in Figure 21.

6.4 Terms and definitions of support surface measures in the transverse view

6.4.1 Support surface reference position in the transverse view



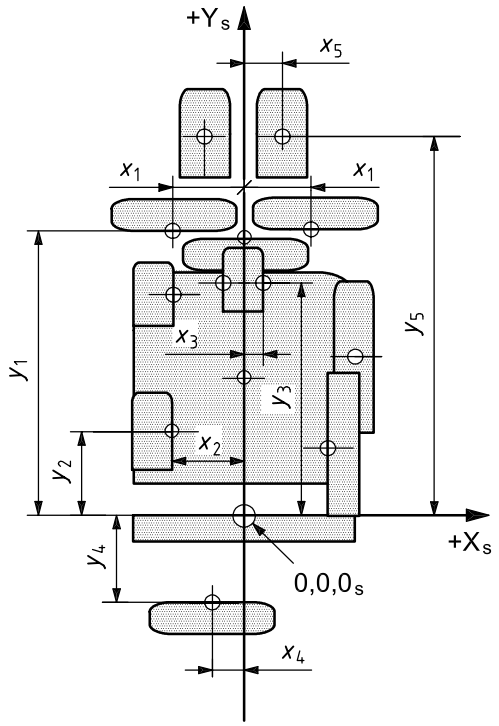
Key

1	posterior support (PS)	4	medial support (MS)
2	anterior support (AS)	5	inferior support (IS)
3	lateral support (LS)		

Figure 22 — Transverse view of generic support surfaces in the SSRP

6.4.2 Coordinate locations of support surfaces in the transverse view

The transverse location of a seating support surface is defined by the X and Y coordinates of the SSGC relative to $0,0,0_s$ origin. Figure 23 and 6.4.2.1 to 6.4.2.6 define location measures of commonly used support surfaces viewed in the transverse plane.



Key

x_1, y_1	anterior support transverse location (AS_{tloc})	x_4, y_4	posterior support transverse location (PS_{tloc})
x_2, y_2	lateral support transverse location (LS_{tloc})	x_5, y_5	inferior support transverse location (IS_{tloc})
x_3, y_3	medial support transverse location (MS_{tloc})		

NOTE Surfaces shown in Figure 23 have been arbitrarily displaced from the SSRP for purposes of illustration.

Figure 23 — Coordinate locations of support surfaces in the transverse view

6.4.2.1
anterior support transverse location
AS_{tloc}
x and y distances from the SSAS origin to the AS support surface geometric centre

See x_1 and y_1 in Figure 23.

6.4.2.2
inferior support transverse location
IS_{tloc}
x and y distances from the SSAS origin to the IS support surface geometric centre

See x_5 and y_5 in Figure 23.

6.4.2.3
lateral support transverse location
LS_{tloc}
x and y distances from the SSAS origin to the LS support surface geometric centre

See x_2 and y_2 in Figure 23.

6.4.2.4
medial support transverse location
MS_{tloc}
x and y distances from the SSAS origin to the MS support surface geometric centre

See x_3 and y_3 in Figure 23.

6.4.2.5
posterior support transverse location
PS_{tloc}
x and y distances from the SSAS origin to the PS support surface geometric centre

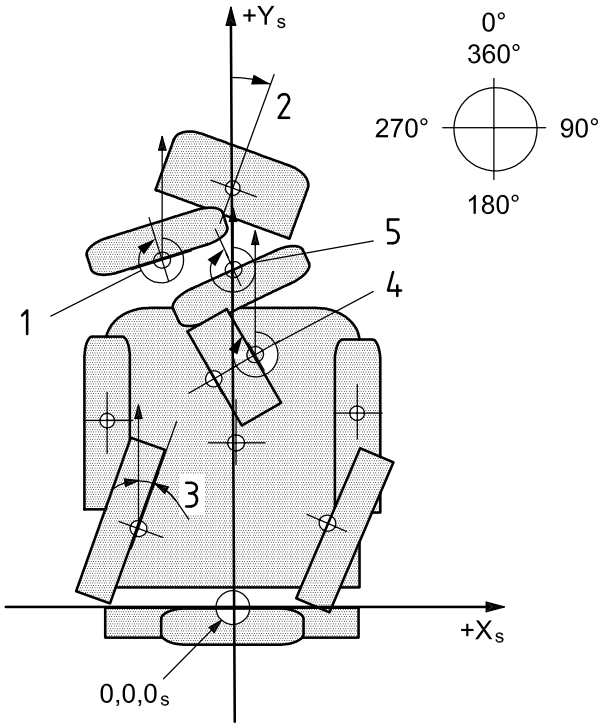
See x_4 and y_4 in Figure 23.

6.4.2.6
superior support transverse location
SS_{tloc}
x and y distances from the SSAS origin to the SS support surface geometric centre

NOTE Not shown in Figure 23.

6.4.3 Absolute angles of generic support surfaces in the transverse plane

The absolute angular position of a seating support surface in the transverse plane is defined as the angle between the +Y axis and the support surface reference line measured in a clockwise direction using 360° notation. The support surface reference line, as specified in 5.4, extends from the SSGC in a manner that allows correlation between the support surface angle and the body segment being supported. Details on specific support surfaces are provided in A.2.4. Figure 24 and 6.4.3.1 to 6.4.3.6 define absolute angle measures of common generic support surfaces when measured in the transverse plane.



Key

1 anterior support transverse angle (AS_{tang})
2 inferior support transverse angle (IS_{tang})
3 lateral support transverse angle (LS_{tang})
4 medial support transverse angle (MS_{tang})
5 posterior support transverse angle (PS_{tang})

NOTE Some surfaces shown in Figure 24 have been arbitrarily displaced from the SSRP for purposes of illustration.

Figure 24 — Examples of absolute angles of generic support surfaces, measured in the transverse plane

6.4.3.1
anterior support transverse angle
AS_{tang}
angle in the XY plane between the +Y axis and the AS support surface reference line for the relevant anterior support surface, as specified in Annex A

See item 1 in Figure 24.

6.4.3.2
inferior support transverse angle
IS_{tang}
angle in the XY plane between +Y axis and the IS support surface reference line for the relevant inferior support surface, as specified in Annex A

See item 2 in Figure 24.

6.4.3.3
lateral support transverse angle
LS_{tang}
angle in the XY plane between the +Y axis and the LS support surface reference line for the relevant lateral support surface, as specified in Annex A

See item 3 in Figure 24.

6.4.3.4
medial support transverse angle
MS_{tang}
angle in the XY plane between +Y axis and the MS support surface reference line for the relevant medial support surface, as specified in Annex A

See item 4 in Figure 24.

6.4.3.5
posterior support transverse angle
PS_{tang}
angle in the XY plane between +Y axis and the PS support surface reference line for the relevant posterior support surface, as specified in Annex A

See item 5 in Figure 24.

6.4.3.6
superior support transverse angle
SS_{tang}
angle in the XY plane between the +Y axis and the SS support surface reference line for the relevant superior support surface, as specified in Annex A

NOTE Not shown in Figure 24.

7 Terms and definitions of body measures of a seated person

7.1 General

Definitions of body measures make up the third component of the integrated measurement system. These measures include absolute and relative angles of body segments and linear measures of a seated person.

7.1.1 Absolute and relative angle measures of a seated person

Body segments, anatomical landmarks, anatomical rotation points (usually joint centres), and the location of a line on each body segment are defined for those body segments critical to defining seated posture. Additional body segments are included in Annex C (informative) that may be used to specify angles of a person's trunk. Lines joining defined body landmarks are used to specify the orientation of a body segment within the global coordinate system defined in 5.2. Measurements of deviations of body segment lines from the designated reference axis of the SSAS, projected to the three defined orthogonal planes permit the measurement and recording of body segment angles. To improve accuracy, four joint centre points are calculated from the positions of anatomical landmarks. These joint centre calculations are specified in Annex B (normative).

In addition to being able to define the spatial orientation of body segments, it is clinically important to be able to differentiate between absolute and relative angles of body segments in each of the three planes, sagittal, frontal and transverse. Absolute angles of body segments reflect the orientation of a body segment in space, whereas relative angles reflect joint position or the angle between two body segments, usually adjacent. Relative angles may be obtained by direct measurement or by calculation using absolute values for the relevant body segments. The subscripts “sang”, “fang” and “tang” are used to identify body segment angles in the sagittal, frontal and transverse planes, respectively.

NOTE Relative angles are defined for measurements only in the sagittal plane, as measures in the other two planes are rarely used in practice. There will be cases involving severe orthopaedic deformities in which it might be appropriate to measure relative angles in the frontal and transverse planes in addition to those in the sagittal plane.

7.1.2 Linear measures of a seated person

The second necessary component for the specification of support surfaces involves the use of linear body measures. Linear measures of the body are defined using external or surface landmarks rather than the body segment lines discussed in 7.1.1. This is required due to the importance of accounting for soft tissue when performing these measures for accurate fit of seating supports.

7.2 Terms and definitions of body measures in the sagittal plane

7.2.1 Body segments and segment lines in the sagittal plane

Tables 1 and 2, and Figures 25 to 27, define the body segments and segment lines required for the specified body measures.

Table 1 — Terms and definitions of body segments and lines in the sagittal plane

Segment line term and definition	Landmarks defining the segment line	See Figures 25, 26 and 27	Anatomical description of landmark (all landmarks are on the right side of the body)
Sagittal head line (perpendicular to A-B) line perpendicular to the line passing through the tragion and eye corner	Tragion	A	The most anterior superior notch of the ear, located at the upper edge of the external auditory meatus
	Eye corner	B_R	Lateral corner of eye formed by the meeting of the upper and lower eyelids (ectocanthus)
Sagittal neck line (D-C) line passing through the lateral upper and lower neck points	Lateral upper neck point[a]	C	A point located by calculation (see B.3) and projected to the lateral surface of the neck
	Lateral lower neck point[a]	D	A point located by calculation (see B.4) and projected to the lateral surface of the neck
Sagittal upper trunk line (J-D) line passing through the lateral lower neck point and the iliac crest point	Lateral lower neck point[a]	D	See above
	iliac crest point	J	The point at which the sagittal pelvic line (see below) crosses the iliac crest
Sagittal pelvic line (M-J) line perpendicular to the ASIS – PSIS line and passing through the lateral hip centre point	ASIS	L	Most anterior–superior prominence of the right ASIS
	PSIS	K	The most posterior prominence on the right PSIS adjacent to the sacrum
	Lateral hip centre point[a]	M	A point located by calculation (see B.2) and projected to the lateral surface of the hip (approximated by the greater trochanter)
	Iliac crest point	J	The point at which the sagittal pelvic line crosses the iliac crest
Sagittal trunk line (M-D) line passing through the lateral lower neck point and the lateral hip centre point	Lateral lower neck centre point[a]	D	See above
	Lateral hip centre point[a]	M	A point located by calculation (see B.2) and projected to the lateral surface of the hip (approximated by the greater trochanter)
Sagittal thigh line (M-N) line passing through the lateral hip centre point and the lateral femoral condyle	Lateral hip centre point[a]	M	See above
	Lateral femoral condyle	N	Point at most lateral aspect of the lateral femoral condyle
Sagittal leg line (N-O) line passing through the lateral femoral condyle and the lateral malleolus	Lateral femoral condyle	N	See above
	Lateral malleolus	O	Point at most lateral aspect of lateral malleolus

Table 1 (*continued*)

Segment line term and definition	Landmarks defining the segment line	See Figures 25, 26 and 27	Anatomical description of landmark (all landmarks are on the right side of the body)
Sagittal foot line (P-Q) line passing through the lateral heel and toe points	Lateral heel point	P	Intersection of sagittal leg line and plantar surface of the foot
	Lateral toe point	Q	Lateral head of 5th metatarsal
Sagittal arm line (G-H) line passing through the lateral shoulder centre point and the lateral humeral epicondyle.	Lateral shoulder centre point[a]	G	A point located by calculation as defined in B.5 and projected to the lateral surface of the humerus just below the acromion process
	Lateral humeral epicondyle	H	Most lateral aspect of lateral humeral epicondyle
Sagittal forearm line (H-I) line passing through the lateral humeral epicondyle and the lateral wrist point.	Lateral humeral epicondyle	H	See above
	Lateral wrist point	I	Inferior aspect of styloid process with forearm in full pronation
Sagittal hand line (I-DD) line passing through the lateral wrist point and lateral hand point	Lateral wrist point	I	See above
	Lateral hand point	DD	Lateral point of fifth metacarpal-phalangeal joint

[a] Denotes landmarks located by calculation, all others are located by palpation.

7.2.2 Seated reference position in the sagittal view

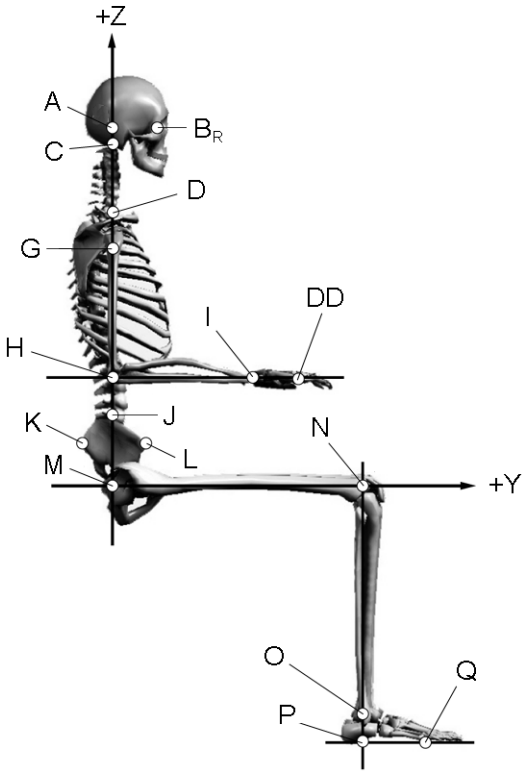


Figure 25 — Body segments and segment lines in the sagittal SRP

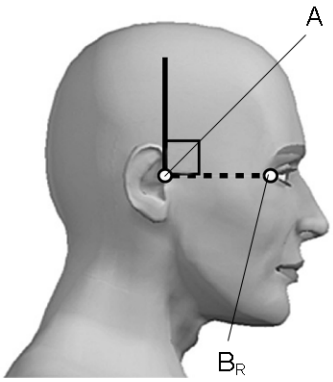


Figure 26 — Sagittal head landmarks and segment line

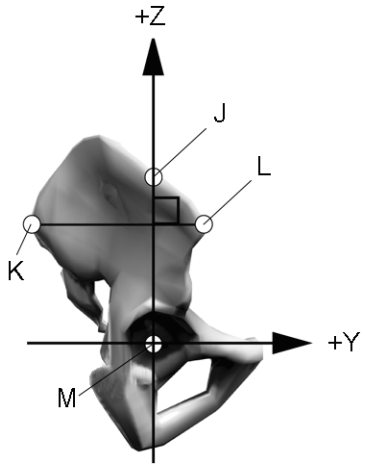


Figure 27 — Sagittal pelvis landmarks and segment lines

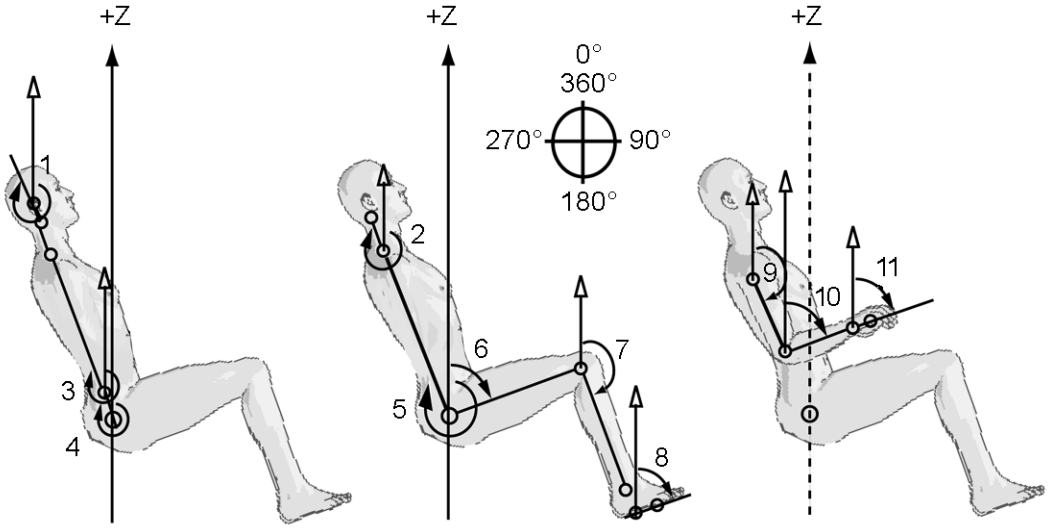
Table 2 — Orientation of body segments and segment lines in the sagittal SRP

Segment	Body segment line	Location of axis of rotation	Orientation to the Z axis in the SRP degrees	Reference
Head	perpendicular to A-B	A	0	Figure 26
Neck	D-C	D	0	Figure 25
Upper trunk	J-D	J	0	Figure 25
Pelvis	M-J	M	0	Figure 27
Trunk	M-D	M	0	Figure 25
Thigh	M-N	M	90	Figure 25
Leg	N-O	N	180	Figure 25
Foot	P-Q	P	90	Figure 25
Arm	G-H	G	180	Figure 25
Forearm	H-I	H	90	Figure 25
Hand	I-DD	I	90	Figure 25

7.2.3 Absolute angles of body segments in the sagittal plane

The angular position of a body segment in the sagittal (YZ) plane is defined as the angle between the vertical +Z axis and the sagittal body segment line of that segment, as viewed from the person's right side and measured in a clockwise direction. When body segments have right and left members, the left side is measured as if viewed from the right. Figure 28 and 7.2.3.1 to 7.2.3.11 specify various absolute angle measures in the sagittal plane.

NOTE In cases where a body segment has a deviation from the sagittal plane, sagittal angle measures are projected to the sagittal plane.



Key

1	sagittal head angle	5	sagittal trunk angle	9	sagittal arm angle
2	sagittal neck angle	6	sagittal thigh angle	10	sagittal forearm angle
3	sagittal upper trunk angle	7	sagittal leg angle	11	sagittal hand angle
4	sagittal pelvic angle	8	sagittal foot angle		

NOTE This figure illustrates absolute angles of selected body segments positioned in an arbitrary orientation.

Figure 28 — Examples of absolute angle measures of body segments in the sagittal plane

7.2.3.1
sagittal head angle
HD_{sang}
angular position of the head defined by the angle between the vertical axis, +Z, and the sagittal head line

See item 1 in Figure 28.

7.2.3.2
sagittal neck angle
NK_{sang}
angular position of the neck segment defined by the angle between the vertical axis, +Z, and the sagittal neck line

See item 2 in Figure 28.

7.2.3.3
sagittal upper trunk angle
UTK_{sang}
angular position of the upper trunk segment defined by the angle between the vertical axis, +Z, and the sagittal upper trunk line

See item 3 in Figure 28.

7.2.3.4
sagittal pelvic angle
PEL_{sang}
angular position of the pelvis defined by the angle between the vertical axis, +Z, and the sagittal pelvic line

See item 4 in Figure 28.

NOTE Where item 5 is 0°, values between 0° and 90° represent anterior pelvic tilt and values between 270° and 360° represent posterior pelvic tilt.

7.2.3.5
sagittal trunk angle
TK_{sang}
angular position of the whole trunk or torso defined by the angle between the vertical axis, +Z, and the sagittal trunk line

See item 5 in Figure 28.

7.2.3.6
sagittal thigh angle
THI_{sang}
angular position of the thigh segment defined by the angle between the vertical axis, +Z, and the sagittal thigh line

See item 6 in Figure 28.

7.2.3.7
sagittal leg angle
LG_{sang}
angular position of the leg segment defined by the angle between the vertical axis, +Z, and the sagittal leg line

See item 7 in Figure 28.

7.2.3.8
sagittal foot angle
FT_{sang}
angular position of the foot segment defined by the angle between the vertical axis, +Z, and the sagittal foot line

See item 8 in Figure 28.

7.2.3.9
sagittal arm angle
ARM_{sang}
angular position of the upper arm segment defined by the angle between the vertical axis, +Z, and the sagittal arm line

See item 9 in Figure 28.

7.2.3.10
sagittal forearm angle
$FARM_{sang}$
angular position of the forearm segment defined by the angle between the vertical axis, +Z, and the sagittal forearm line

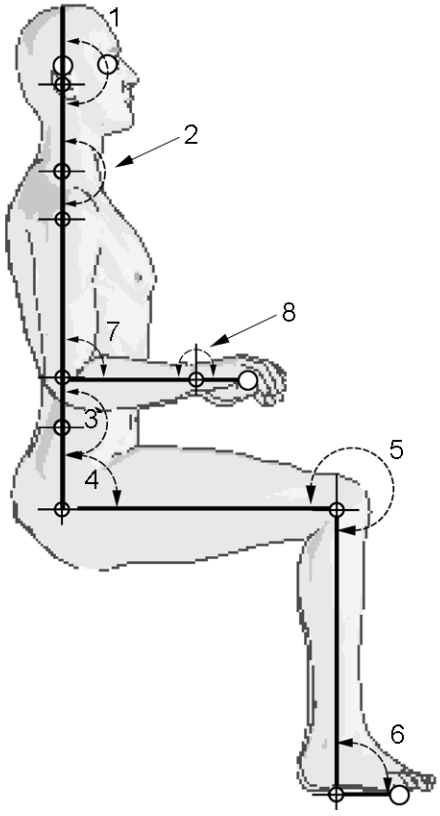
See item 10 in Figure 28.

7.2.3.11
sagittal hand angle
HN_{sang}
angular position of the hand segment defined by the angle between the vertical axis, +Z, and the sagittal hand line

See item 11 in Figure 28.

7.2.4 Relative angles of body segments in the sagittal plane

Relative angles of body segments are defined as the angle formed between two body segments, usually adjacent segments, measured on the anterior/superior side of the relative segments. Relative angles between body segments reflect a static joint position and posture. Figure 29, Table 3 and 7.2.4.1 to 7.2.4.10 specify commonly used relative angles of body segments.



Key

1	head to neck angle	4	pelvic to thigh angle	7	arm to forearm angle
2	neck to upper trunk angle	5	thigh to leg angle	8	forearm to hand angle
3	upper trunk to pelvic angle	6	leg to foot angle		

Figure 29 — Examples of commonly used relative angles in the sagittal SRP

Table 3 — Commonly used relative angles and values in the sagittal SRP

Segments	Segment lines[a]	Location of axis[a]	Relative angle value in the SRP degrees
Head to neck	D-C and perpendicular to A-B	C	180
Neck to upper trunk	D-C and J-D	D	180
Upper trunk to pelvic	J-D and M-J	J	180
Pelvic to thigh	M-J and M-N	M	90
Thigh to leg	M-N and N-O	N	270
Leg to foot	N-O and P-Q	O	90
Arm to forearm	G-H and H-I	H	90
Forearm to hand	H-I and I-DD	I	180

[a] See Table 1 and Figures 25, 26 and 27 for more information.

7.2.4.1
sagittal head to neck angle
$(HD\text{-}NK)_{sang}$
angle formed between the sagittal head line and the sagittal neck line

See item 1 in Figure 29.

7.2.4.2
sagittal neck to upper trunk angle
$(NK\text{-}UTK)_{sang}$
angle formed between the sagittal neck line and the sagittal upper trunk line

See item 2 in Figure 29.

7.2.4.3
sagittal upper trunk to pelvis angle
$(UTK\text{-}PS)_{sang}$
angle formed between the sagittal upper trunk line and the sagittal pelvic line

See item 3 in Figure 29.

7.2.4.4
sagittal pelvis to thigh angle
$(PS\text{-}THI)_{sang}$
angle formed between the sagittal pelvic line and the sagittal thigh line

See item 4 in Figure 29.

7.2.4.5
sagittal trunk to thigh angle
$(TK\text{-}THI)_{sang}$
angle formed between the sagittal trunk line and the sagittal thigh line

NOTE Not shown in Figure 29.

7.2.4.6
sagittal thigh to leg angle
$(THI\text{-}LG)_{sang}$
angle formed between the sagittal thigh line and the sagittal leg line

See item 5 in Figure 29.

7.2.4.7
sagittal leg to foot angle
$(LG\text{-}FT)_{sang}$
angle formed between the sagittal leg line and the sagittal foot line

See item 6 in Figure 29.

7.2.4.8
sagittal trunk to arm angle
$(TK\text{-}ARM)_{sang}$
angle formed between the sagittal trunk line and the sagittal arm line

NOTE Not shown in Figure 29.

7.2.4.9
sagittal arm to forearm angle
$(ARM\text{-}FARM)_{sang}$
angle formed between the sagittal arm line and the sagittal forearm line

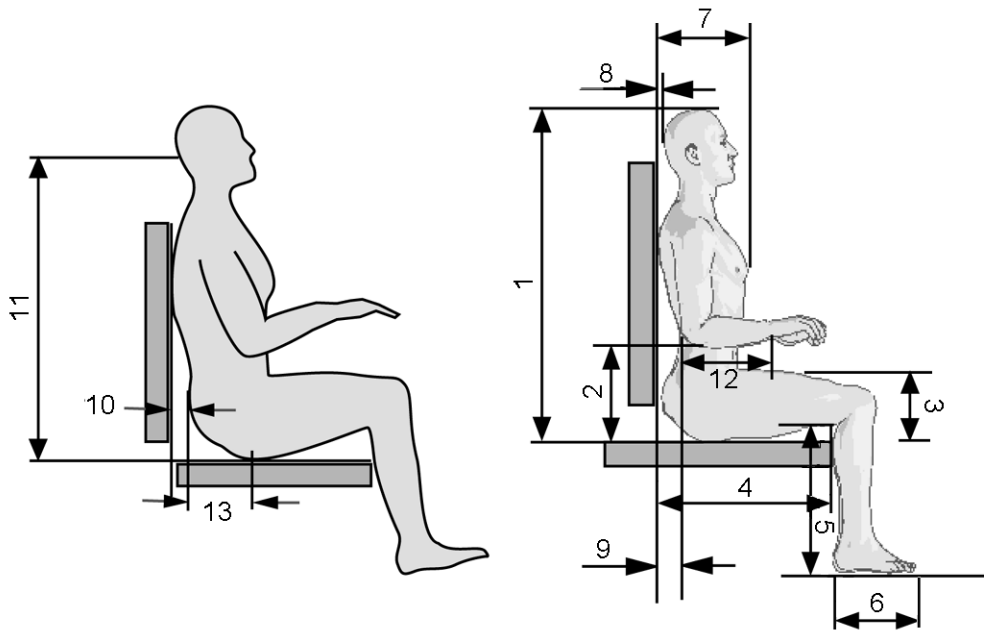
See item 7 in Figure 29.

7.2.4.10
sagittal forearm to hand angle
$(FARM\text{-}HND)_{sang}$
angle formed between the sagittal forearm line and the sagittal hand line

See item 8 in Figure 29.

7.2.5 Linear measures of body segments in the sagittal view

Linear measures of the body are defined using external or surface landmarks rather than the body segment lines defined in 7.2.1. This is required due to the importance of accounting for soft tissue when performing these measures for accurate fit of seating supports. Figure 30 and 7.2.5.1 to 7.2.5.13 define linear measures in the sagittal view commonly used for seated postural assessment.



Key

1	maximum sitting height	6	foot depth	11	occiput height
2	elbow height	7	trunk depth	12	forearm length
3	thigh clearance	8	occiput depth	13	ischial depth
4	buttock/thigh depth	9	lumbar curve depth		
5	lower leg length	10	thoracic curve depth		

Figure 30 — Linear measures in sagittal view

7.2.5.1
maximum sitting height
SH
vertical distance from a horizontal sitting surface to the highest point of the head

See item 1 in Figure 30.

NOTE Same as ISO 7250:1996, 4.2.1, sitting height (erect).

7.2.5.2
elbow height, right or left
EH_R, EH_L
vertical distance from a horizontal sitting surface to the lowest bony point of the elbow

See item 2 in Figure 30.

NOTE This is similar to ISO 7250:1996, 4.2.5, elbow height, sitting.

7.2.5.3
thigh clearance, right or left
THC_R, THC_L
vertical distance from the sitting surface to the highest point on the thigh

See item 3 in Figure 30.

NOTE Same as ISO 7250:1996, 4.2.13, thigh clearance.

7.2.5.4
buttock/thigh depth, right or left
BD_R, BD_L
horizontal distance from the most posterior point of the buttocks to the popliteal fossa, measured parallel to the sagittal thigh line and perpendicular to the X axis

See item 4 in Figure 30.

NOTE This is equivalent to ISO 7250:1996, 4.4.6, buttock-popliteal length (seat depth).

7.2.5.5
lower leg length, right or left
LL_R, LL_L
maximum distance from the inferior surface of the thigh immediately behind knee to the inferior surface of the heel measured parallel to the sagittal leg line

See item 5 in Figure 30.

NOTE This is similar to ISO 7250:1996, 4.2.12, lower leg length (popliteal height).

7.2.5.6
foot depth, right or left
FD_R, FD_L
maximum distance from rear of the heel to tip of the longest toe; measured parallel to the sagittal foot line

See item 6 in Figure 30.

7.2.5.7
trunk depth
TD
maximum depth of the torso from the most posterior point of the thorax to the most anterior point of the sternum measured perpendicular to the sagittal trunk line

See item 7 in Figure 30.

7.2.5.8
occiput depth
OD
maximum distance from the most posterior point of the thorax to the occipital protuberance on posterior surface of head

See item 8 in Figure 30.

NOTE There will be times when it is important to differentiate an occipital position forward of the thorax from a position behind the thorax, in order to accomplish this, when head is anterior to trunk, value is positive, when head is posterior to trunk, value is negative.

7.2.5.9
occiput height
OH
distance from the seat support reference plane to the lowest point of the occipital protuberance measured parallel to the sagittal trunk line

See item 11 in Figure 30.

7.2.5.10
lumbar curve depth
LCD
distance from the most posterior point of the buttocks to the spinous process of the most anterior point of the lumbar spine measured perpendicular to the sagittal trunk line

See item 9 in Figure 30.

NOTE There will be times when it is important to differentiate a lumbar position forward of the buttocks from a position behind the buttocks. In order to accomplish this, when lumbar curve is anterior to buttocks, value is positive, when lumbar curve is posterior to buttocks, value is negative.

7.2.5.11
thoracic curve depth
TCD
distance from the most posterior point of the buttocks to the most posterior point of the thorax measured perpendicular to the sagittal trunk line

See item 10 in Figure 30.

NOTE There will be times when it is important to differentiate a thoracic position forward of the buttocks from a position behind the buttocks, in order to accomplish this, when thoracic curve is anterior to the posterior surface of the buttocks, value is positive, when thoracic curve is posterior to the posterior surface of the buttocks, value is negative.

7.2.5.12
forearm length, right or left
FL_R, FL_L
maximum distance from the most posterior point of the elbow to the styloid process of the wrist

See item 12 in Figure 30.

7.2.5.13
ischial depth, right or left
ID_R, ID_L
distance from the most posterior point of the buttocks to the most anterior point of the ischium measured parallel to the sagittal thigh line and perpendicular to the X axis

See item 13 in Figure 30.

7.3 Terms and definitions of body measures in the frontal view

7.3.1 Body segments and segment lines in the frontal view

Tables 4 and 5, and Figures 31 and 32, define the body segments and segment lines required for the defined body measures in the frontal plane.

Table 4 — Terms and definitions of body segments and lines in the frontal plane

Segment line term and definition	Landmarks defining the segment line	See Figures 31 and 32	Anatomical description of landmark
Frontal head line (perpendicular to B_R-B_L) line perpendicular to the line passing between the right and left eye corners	Right eye corner	B_R	Lateral corner of the right eye formed by the meeting of the upper and lower eyelids (ectocanthus)
	Left eye corner	B_L	Lateral corner of the left eye formed by the meeting of the upper and lower eyelids (ectocanthus)
	Eye corner midpoint	B	Midpoint of line B_R-B_L
Frontal neck line (D-C) line passing through the upper and lower neck points (approximately base of nose to suprasternal notch)	Upper neck point[a]	C	The calculated upper neck centre (see B.3) projected to the anterior surface (approximately at the base of the nose)
	Lower neck point[a]	D	The calculated lower neck centre (see B.4) projected horizontally to the anterior surface (just above the suprasternal notch)
Frontal trunk line (X-U) line passing through the upper sternal notch and the ASIS midpoint	Upper sternal notch	U	Superior margin of the sternum (suprasternal notch)
	ASIS midpoint[a]	X	Midpoint of the line between the right ASIS and left ASIS
Frontal sternum line (V-U) line passing through the upper sternal notch and the lower sternal notch	Upper sternal notch	U	See above
	Lower sternal notch	V	Point at inferior margin of sternum
Frontal pelvic line (perpendicular to L_R-L_L) line perpendicular to the line passing through the right ASIS and left ASIS, passing through the ASIS midpoint	Right ASIS	L_R	The most anterior-superior prominence of the right anterior superior iliac spine projected to the anterior surface of the body
	Left ASIS	L_L	The most anterior-superior prominence of the left anterior superior iliac spine projected to the anterior surface of the body
	ASIS midpoint	X	Midpoint of the line between the right ASIS and left ASIS (L_R-L_L)
Frontal leg line (Y_R-Z_R, Y_L-Z_L) line connecting the anterior knee and ankle points	Anterior knee point	Y_R Y_L	Midpoint between medial and lateral femoral condyles projected to anterior surface of the knee (approximately mid-patellae)
	Anterior ankle point	Z_R Z_L	Midpoint between lateral and medial malleoli projected to the anterior surface of the ankle
Frontal foot line (perpendicular to BB_R-AA_R, BB_L-AA_L) line perpendicular to the line passing through the medial and lateral foot points (on plantar surface of the foot)	Medial foot point	BB_R BB_L	Inferior border of the head of the 1st metatarsal
	Lateral foot point	AA_R AA_L	Inferior border of the head of the 5th metatarsal
Frontal arm line (T_R-W_R, T_L-W_L) line passing through the anterior shoulder and elbow points	Right and left anterior shoulder points	T_R T_L	Front of the shoulder at the bicipital groove – left and right arms
	Anterior elbow point	W_R W_L	Midpoint between medial and lateral humeral epicondyles in the cubital fossa
Frontal hand line (perpendicular to DD_R-FF_R, DD_L-FF_L) line perpendicular to the line passing through the lateral and medial hand points at the level of the superior hand points (EE_R, EE_L)	Lateral hand point	DD_R DD_L	Lateral point of the fifth metacarpal-phalangeal joint
	Medial hand point	FF_R FF_L	Medial point of the second metacarpal-phalangeal joint
	Superior hand point	EE_R EE_L	Base of the third metacarpal phalangeal joint (centre of rotation for the hand segment)

[a] Denotes landmarks located by calculation. All others are located by palpation.

7.3.2 Seated reference position in the frontal plane

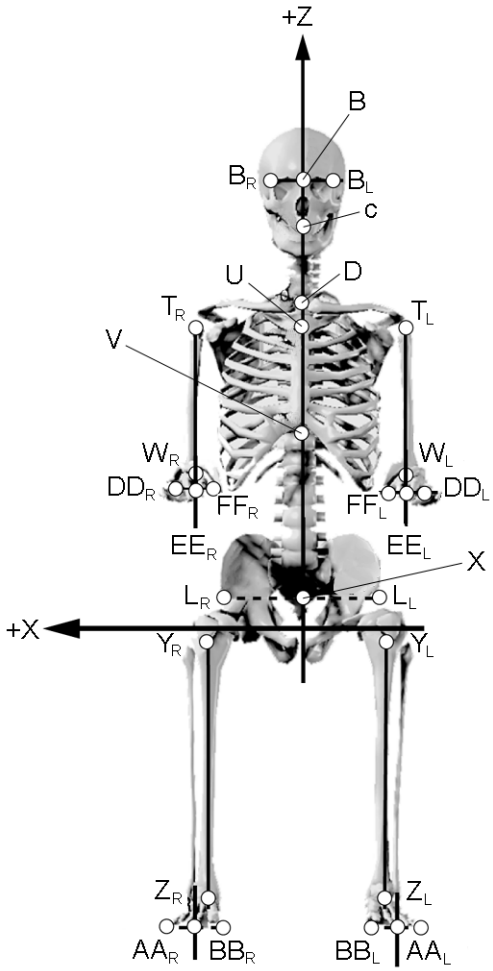


Figure 31 — Body segments and segment lines in the frontal SRP

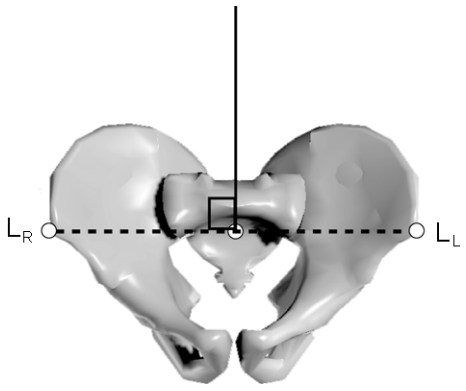


Figure 32 — Frontal pelvic line

Table 5 — Body segment lines in the frontal SRP

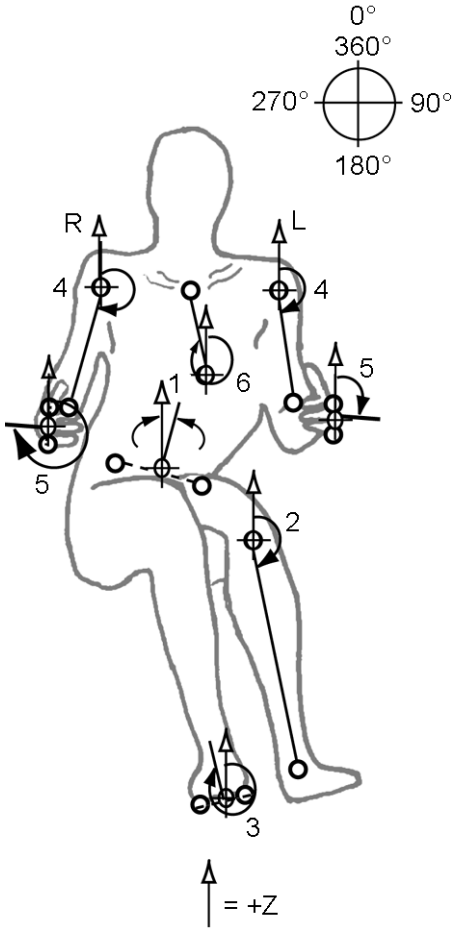
Segment	Body segment line[a]	Location of axis of rotation[a]	Orientation to the +Z axis in the SRP degrees
Head	perpendicular to B_R-B_L	midpoint of B_R-B_L line	0
Neck	D-C	D	0
Trunk	X-U	X	0
Sternum	V-U	V	0
Pelvis	perpendicular to L_R-L_L	X	0
Leg	Y_R-Z_R Y_L-Z_L	Y_R Y_L	180 180
Foot	perpendicular to AA -BB lines (right and left)	midpoint of AA-BB lines (right and left)	0 0
Arm	T_R-W_R T_L-W_L	T_R T_L	180 180
Hand	perpendicular to DD - FF lines (right and left)	EE_R EE_L	0 0

[a] See Table 4 and Figures 31 and 32 for more information.

7.3.3 Absolute angles of body segments in the frontal plane

The angular position of a body segment in the frontal (ZX) plane is defined as the angle between the vertical +Z axis and the frontal body segment line of that segment, as viewed from the person's front and measured in a clockwise direction. Figure 33 and 7.3.3.1 to 7.3.3.9 specify various absolute angle measures in the frontal plane.

NOTE In cases where a body segment has a deviation from the frontal plane, frontal angle measures are projected to the frontal plane.



Key

1	frontal pelvic angle	3	frontal foot angle (R)	5	frontal hand angle (L and R)
2	frontal leg angle (L)	4	frontal arm angle (L and R)	6	frontal sternal angle

Figure 33 — Examples of absolute angles of the body in the frontal plane

7.3.3.1
frontal head angle
HD_{fang}
angular position of the head segment defined by the angle between the vertical axis, +Z, and the frontal head line

NOTE Not shown in Figure 33.

7.3.3.2
frontal neck angle
NK_{fang}
angular position of the neck segment defined by the angle between the vertical axis, +Z, and the frontal neck line

NOTE Not shown in Figure 33.

7.3.3.3
frontal sternal angle
ST_{fang}
angular position of the sternal segment in the frontal plane, defined by the angle between the vertical axis, +Z, and the frontal sternal line

See item 6 in Figure 33.

7.3.3.4
frontal pelvic angle
PEL_{fang}
angular position of the pelvis defined by the angle between the vertical axis, +Z, and the frontal pelvic line

See item 1 in Figure 33.

NOTE This term is also referred to as pelvic obliquity. Values between 270° and 360° represent right ASIS lower than left, (right obliquity) values between 0° and 90° represent left ASIS lower than right (left obliquity).

7.3.3.5
frontal trunk angle
TK_{fang}
angular position of the trunk segment defined by the angle between the vertical axis, +Z, and the frontal trunk line

NOTE Not shown in Figure 33.

7.3.3.6
frontal leg angle
LG_{fang}
angular position of the lower leg segment defined by the angle between the vertical axis, +Z, and the frontal leg line

See item 2 in Figure 33.

7.3.3.7
frontal foot angle
FT_{fang}
angular position of the foot segment defined by the angle between the vertical axis, +Z, and the frontal foot line

See item 3 in Figure 33.

7.3.3.8
frontal arm angle
ARM_{fang}
angular position of the upper arm segment defined by the angle between the vertical axis, +Z, and the frontal arm line

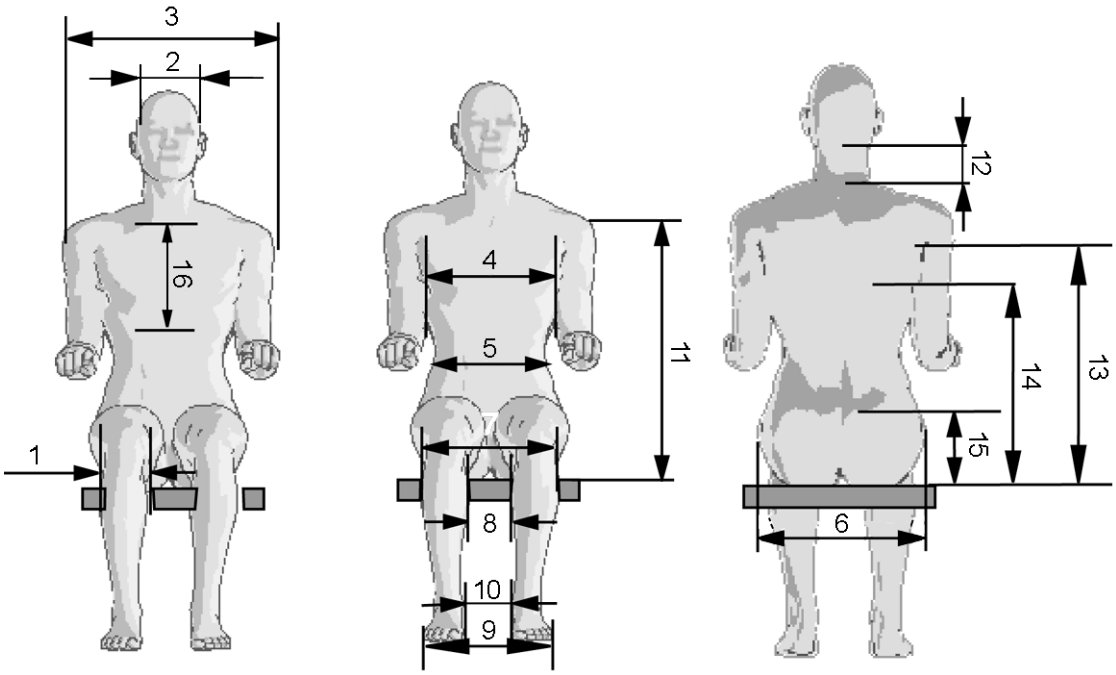
See item 4 in Figure 33.

7.3.3.9
frontal hand angle
HN_{fang}
angular position of the hand segment defined by the angle between the vertical, +Z, axis and the frontal hand line

See item 5 in Figure 33.

7.3.4 Linear measures of the body in the frontal view

Linear measures of the body are defined using external or surface landmarks rather than the body segment lines defined in 7.3.1. This is required due to the importance of accounting for soft tissue when performing these measures for accurate fit of seating supports. Figure 34 and 7.3.4.1 to 7.3.4.18 specify examples of linear measures of the body in the frontal view. For defining widths for body positions outside the SRP, it is necessary to take projections from the specified surface landmarks along the Y axis. A width measure is the minimum distance between these two projections.



Key

1	knee width	5	waist width	9	external foot width	13	axilla height
2	head width	6	hip width	10	internal foot separation	14	scapula height
3	shoulder width	7	external knee width	11	shoulder height	15	PSIS height
4	chest width	8	internal knee separation	12	occiput to C7	16	sternal length

Figure 34 — Examples of linear measures in frontal view

7.3.4.1
knee width
KnW
maximum width of the knee measured at the level of the femoral condyles

See item 1 in Figure 34.

7.3.4.2
head width
HdW
maximum width of head above the ears

See item 2 in Figure 34.

7.3.4.3
shoulder width
SW
maximum width of the shoulders taken from the outer borders of the upper arms with the arms at the sides

See item 3 in Figure 34.

7.3.4.4
chest width
CW
width of the torso measured at the midpoint between the upper and lower sternal notches

See item 4 in Figure 34.

7.3.4.5
waist width
WW
width of the waist measured at the level of the umbilicus

See item 5 in Figure 34.

7.3.4.6
hip width
HiW
width of the hips including soft tissue measured at the level of the greater trochanters

See item 6 in Figure 34.

7.3.4.7
thigh width
TW
maximum width of the lower body measured at the widest point along the thighs

NOTE Not shown in Figure 34.

7.3.4.8
external knee width
EKnW
distance between the lateral surfaces of the knees measured at the lateral femoral condyles

See item 7 in Figure 34.

7.3.4.9
internal knee separation
IKnS
distance between the medial surfaces of the knees measured at the medial femoral condyles

See item 8 in Figure 34.

7.3.4.10
external foot width
EFW
distance between the outer borders of the left and right feet, measured at most anterior-lateral point on forefoot

See item 9 in Figure 34.

7.3.4.11
internal foot separation
IFS
distance between the inner borders of the left and right feet, measured at most anterior-medial point on forefoot

See item 10 in Figure 34.

7.3.4.12
shoulder height
SH_R, SH_L
distance from the sitting surface under buttocks to each acromion process, measured parallel to the sagittal trunk line and perpendicular to the X axis

See item 11 in Figure 34.

NOTE 1 Shoulder height may be measured left and right.

NOTE 2 This term is similar to ISO 7250:1996, 4.2.4, shoulder height, sitting.

7.3.4.13
occiput to C7
OC7
distance between occipital protuberance and C7 measured parallel to the sagittal trunk line and perpendicular to the X axis

See item 12 in Figure 34.

7.3.4.14
axilla height
AxH_R, AxH_L
distance from the sitting surface under buttocks to the axilla measured parallel to the sagittal trunk line and perpendicular to the X axis

See item 13 in Figure 34.

NOTE Axilla height may be measured left and right.

7.3.4.15
scapula height
$ScapH_R$, $ScapH_L$
distance from the sitting surface under buttocks to the inferior angle of the scapula measured parallel to the sagittal trunk line and perpendicular to the X axis

See item 14 in Figure 34.

NOTE Scapula height may be measured left and right.

7.3.4.16
PSIS height
$PSISH_R$, $PSISH_L$
distance from the sitting surface under buttocks to the PSIS measured parallel to the sagittal trunk line and perpendicular to the X axis

See item 15 in Figure 34.

NOTE PSIS height may be measured left and right.

7.3.4.17
occipital protuberance to vertical centreline
OtoC
horizontal distance from the occipital protuberance to the back support vertical centreline

7.3.4.18
sternal length
SternL
distance from the lower sternal notch to the upper sternal notch

See item 16 in Figure 34.

7.4 Terms and definitions of body measures in the transverse plane

7.4.1 Body segments and segment lines in the transverse plane

Tables 6 and 7, and Figures 35 and 36, specify the body segments and segment lines required for the defined body measures in the transverse plane.

Table 6 — Terms and definitions of body segments and lines in the transverse plane

Segment line term/definition	Landmarks defining the segment line	See Figures 35 and 36	Anatomical description of landmark
Transverse head line (perpendicular to A_R-A_L) line perpendicular to the line connecting the right and left Tragions at the midpoint of this line	Right tragion	A_R	The most anterior superior notch of the right ear, located at the upper edge of the external auditory meatus
	Left tragion	A_L	The most anterior superior notch of the left ear, located at the upper edge of the external auditory meatus
Transverse trunk/shoulder line (perpendicular to R_R-R_L) line perpendicular to the line passing through the right and left acromion points at the midpoint of this line	Right Acromion Point	R_R	The most anterior lateral prominence of the right acromion process
	Left acromion point	R_L	The most anterior lateral prominence of the left acromion process
Transverse pelvic line (perpendicular to L_R-L_L) line perpendicular to the line passing through the right and left ASIS's at the midpoint of this line	Right ASIS	L_R	The most anterior-superior prominence of the right anterior superior iliac spine
	Left ASIS	L_L	The most anterior-superior prominence of the left anterior superior iliac spine
Transverse thigh line (L_R-N_R; L_L-N_L): line passing through the ASIS and superior knee point	ASIS	L_L L_R	See above
	Superior knee point	N_R N_L	Midpoint between medial and lateral femoral condyles projected to the superior surface of the knee
Transverse foot line (O_R-S_R; O_L-S_L): line passing through the anterior ankle point and the superior toe point	Anterior ankle point	O_R O_L	Midpoint of line between malleoli projected to anterior surface of ankle joint
	Superior toe point	S_R S_L	Midpoint between base of 2nd and 3rd metatarsal heads
Transverse forearm line (CC_R-II_R; CC_L-II_L): line passing through the anterior elbow point and the superior wrist point	Anterior elbow point	CC_R CC_L	Midpoint on line between medial and lateral humeral epicondyles in cubital fossa
	Superior wrist point	II_R II_L	Midpoint between ulnar and radial styloids with fully pronated forearm projected to superior surface of wrist
Transverse hand line (II_R-EE_R; II_L-EE_L): line passing through the superior wrist and hand points	Superior wrist point	II_R II_L	See above
	Superior hand point	EE_R EE_L	Base of the third finger (3rd MCP joint)

7.4.2 Seated reference position in the transverse plane

Body segments in Figure 35 are shown in the SRP, except the upper body which has been displaced posteriorly so pelvic landmarks can be seen.

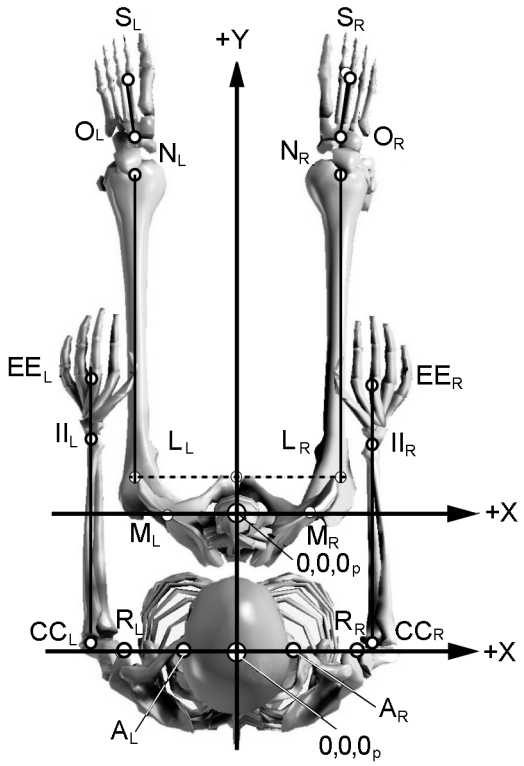


Figure 35 — Body segments and lines in the transverse SRP

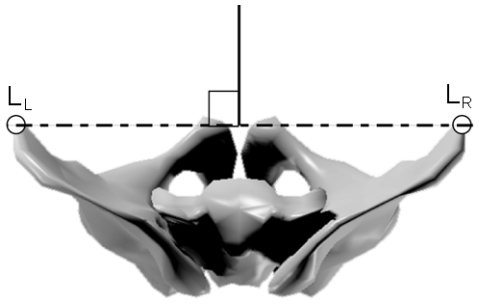


Figure 36 — Transverse pelvic line

Table 7 — Orientation of body segments and segment lines in the transverse SRP

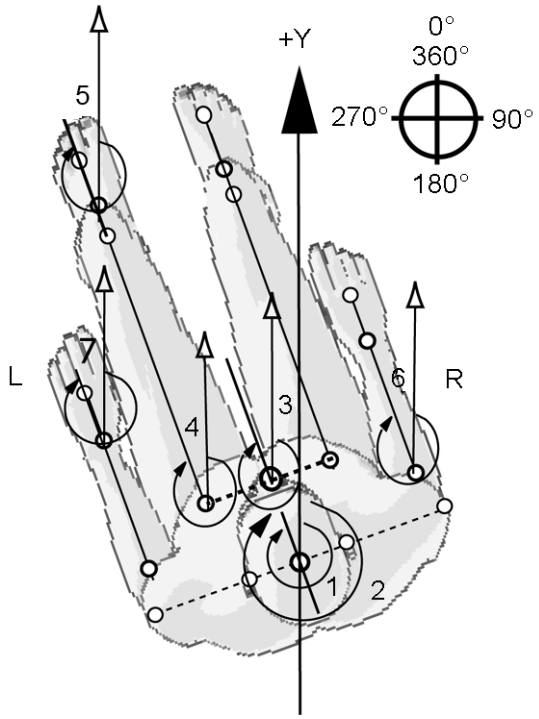
Segment	Body segment line[a]	Location of the axis of rotation[a]	Orientation to the Y axis in the SRP degrees
Head	perpendicular to A_R-A_L	A_R-A_L midpoint	0
Trunk/shoulder	perpendicular to R_R-R_L	R_R-R_L midpoint	0
Pelvis	perpendicular to L_R-L_L	X	0
Thigh	L_R-N_R	L_R	0
	L_L-N_L	L_L	0
Foot	O_R-S_R	O_R	0
	O_L-S_L	O_L	0
Forearm	CC_R-II_R	R_R	0
	CC_L-II_L	R_L	0
Hand	II_R-EE_R	II_R	0
	II_L-EE_L	II_L	0

[a] See Table 6 and Figures 35 and 36 for more information.

7.4.3 Absolute angles of body segments in the transverse plane

The angular position of a body segment in the transverse (XY) plane is defined as the angle between the +Y axis and the transverse body segment line of that segment, as viewed from the person's top and measured in a clockwise direction. Figure 37 and 7.4.3.1 to 7.4.3.7 specify various absolute angle measures in the transverse plane.

NOTE In cases where a body segment has a deviation from the transverse plane, transverse angle measures are projected to the transverse plane.



Key

1	transverse head angle	4	transverse thigh angle	7	transverse hand angle
2	transverse trunk angle	5	transverse foot angle		
3	transverse pelvic angle	6	transverse forearm angle		

Figure 37 — Examples of absolute angles of the body segment measures in the transverse plane

7.4.3.1
transverse head angle
HD_{tang}
angular position of the head segment defined by the angle between the +Y axis and the transverse head line

See item 1 in Figure 37.

7.4.3.2
transverse trunk angle
TK_{tang}
angular position of the trunk segment defined by the angle between the +Y axis and the transverse trunk/shoulder line

See item 2 in Figure 37.

7.4.3.3
transverse pelvic angle
PEL_{tang}
angular position of the pelvis defined by the angle between the +Y axis and the transverse pelvic line

See item 3 in Figure 37.

NOTE This term is also referred to clinically as pelvic rotation. Values between 0° and 90° represent rotation towards the right and values between 270° and 360° represent rotation towards the left.

7.4.3.4
transverse thigh angle
THI_{tang}
angular position of the thigh defined by the angle between the +Y axis and the transverse thigh line

See item 4 in Figure 37.

7.4.3.5
transverse foot angle
FT_{tang}
angular position of the foot defined by the angle between the +Y axis and the transverse foot line

See item 5 in Figure 37.

7.4.3.6
transverse forearm angle
$FARM_{tang}$
angular position of the forearm defined by the angle between the +Y axis and the transverse forearm line

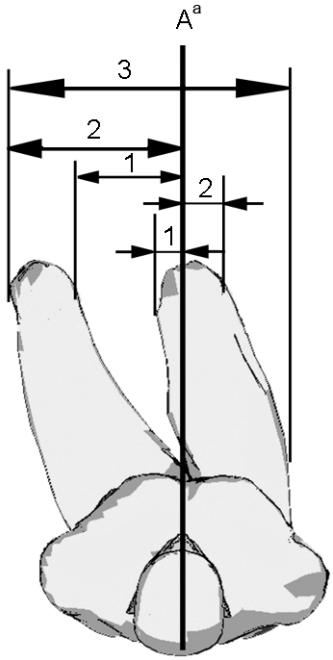
See item 6 in Figure 37.

7.4.3.7
transverse hand angle
HN_{tang}
angular position of the hand defined by the angle between the +Y axis and the transverse hand line

See item 7 in Figure 37.

7.4.4 Linear measures of the body in the transverse view

Linear measures of the body are defined using external or surface landmarks rather than the body segment lines defined in 7.4.1. This is required due to the importance of accounting for soft tissue when performing these measures for accurate fit of seating supports. Figure 38 and 7.4.4.1 to 7.4.4.3 specify examples of linear measures of the body in the transverse view. Measures 7.4.4.1 and 7.4.4.2 are taken from the midsagittal plane, which is a YZ plane passing through the midpoint between the right and left ASIS. For all measures in this view, it is necessary to take projections from the specified surface landmarks parallel with the midsagittal plane. The measure is the minimum distance between these two projections.



Key

1	medial knee to centreline	3	maximum lower body width
2	lateral knee to centreline	A	midsagittal plane

[a] If measures are to the left of line A, they will be negative.

Figure 38 — Examples of linear body measures in the transverse view

7.4.4.1
medial knee to centreline, right and left
MKnC-R, MKnC-L
distance to the right or left from the medial surface of knee to the midsagittal plane, measured at medial femoral condyle parallel to X axis

See item 1 in Figure 38.

NOTE This dimension can be measured for right and left knees.

7.4.4.2
lateral knee to centreline, right and left
LKnC-R, LKnC-L
distance to the right or left from the lateral surface of the knee to the midsagittal plane, measured at the lateral femoral condyle parallel to X axis

See item 2 in Figure 38.

NOTE This dimension can be measured for right and left knees.

7.4.4.3
maximum lower body width
MLB_w
maximum distance between the most lateral part of the left lower body and the most lateral part of the right lower body measured parallel to the X axis of the seat

See item 3 in Figure 38.

Annex A
(normative)

Definition of reference lines for common seating support surfaces

A.1 General principles

Determination of an absolute angle of a support surface requires the identification of a reference line on the support surface to which the angle can be measured. This reference line extends from the support surface geometric centre in a direction which allows measurement of the support surface angle so that it can be correlated with the absolute angle of the body segment it supports.

Tables A.1, A.2 and A.3 specify the support surface, body segment supported, absolute angle of the reference line in the SSRP, and the typical angular ranges for each support surface, in each of the three planes. Figures A.1, A.2 and A.3 provide illustrations showing the reference line orientation in the SSRP for typical support surfaces.

A.2 Terms and definition of support surface reference lines

A.2.1 General

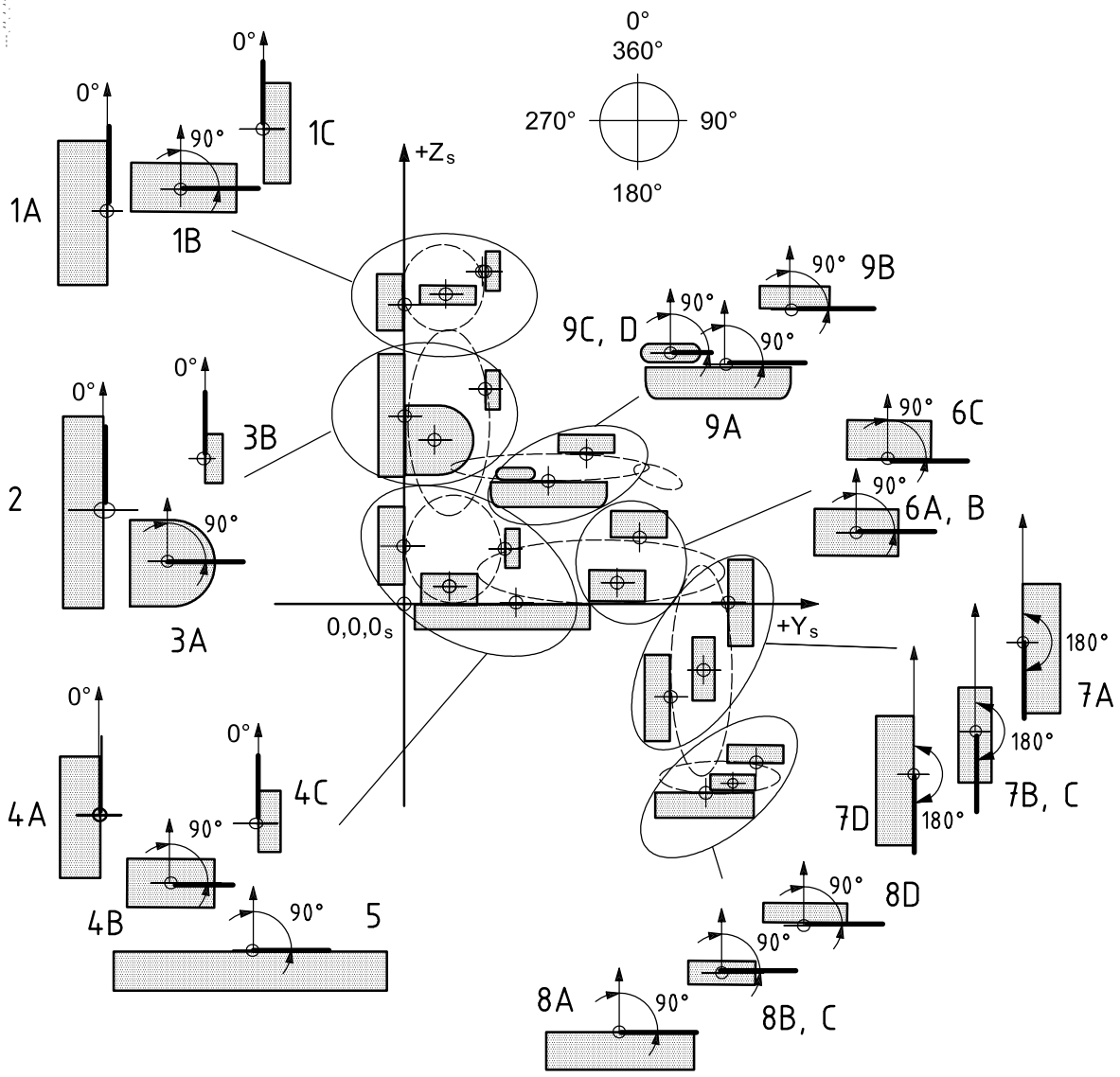
The definitions for posterior, anterior, inferior, superior, lateral and medial support surfaces as specified in 6.2.4, 6.3.4, and 6.4.3 apply equally to the absolute angles of specific support surfaces listed in Tables A.1, A.2 and A.3 below.

A.2.2 Sagittal reference lines

Table A.1 — Orientation of support surface reference lines in the sagittal SSRP

Support surface	Supported body segment	Absolute angle in SSRP degrees	Range of typical angles degrees	Figure A.1 reference
Posterior head	Head	0	300 to 20	1A
Lateral head	Head	90	70 to 110	1B
Anterior head	Head	0	300 to 20	1C
Back	Trunk	0	300 to 20	2
Lateral trunk	Trunk	90	70 to 110	3A
Anterior trunk	Trunk	0	300 to 20	3B
Posterior pelvic	Pelvis	0	300 to 20	4A
Lateral pelvic	Pelvis	90	70 to 110	4B
Anterior pelvic	Pelvis	0	300 to 20	4C
Seat	Pelvis/thigh	90	70 to 110	5
Lateral thigh	Thigh/knee	90	30 to 110	6A
Medial thigh	Thigh/knee	90	30 to 110	6B
Superior thigh	Thigh	90	30 to 110	6C
Anterior leg	Leg/knee	180	160 to 225	7A
Medial leg	Leg	180	90 to 225	7B
Lateral leg	Leg	180	90 to 225	7C
Posterior leg	Leg	180	90 to 225	7D
Inferior foot	Foot	90	60 to 160	8A
Lateral foot	Foot	90	60 to 160	8B
Medial foot	Foot	90	60 to 160	8C
Superior foot	Foot	90	60 to 160	8D
Inferior forearm	Forearm	90	30 to 110	9A
Superior forearm	Forearm	90	30 to 110	9B
Medial forearm	Forearm	90	30 to 110	9C
Lateral forearm	Forearm	90	30 to 110	9D

NOTE All values are in degrees using the 360° measurement method defined in 5.2.3. All sagittal absolute angles are referenced to the +Z axis.



Key

1A	posterior head	5	seat	8A	inferior foot
1B	lateral head	6A	lateral thigh	8B	lateral foot
1C	anterior head	6B	medial thigh	8C	medial foot
2	back	6C	superior thigh	8D	superior foot
3A	lateral trunk	7A	anterior leg	9A	inferior forearm
3B	anterior trunk	7B	medial leg	9B	superior forearm
4A	posterior pelvis	7C	lateral leg	9C	lateral forearm
4B	lateral pelvis	7D	posterior leg	9D	medial forearm
4C	anterior pelvis				

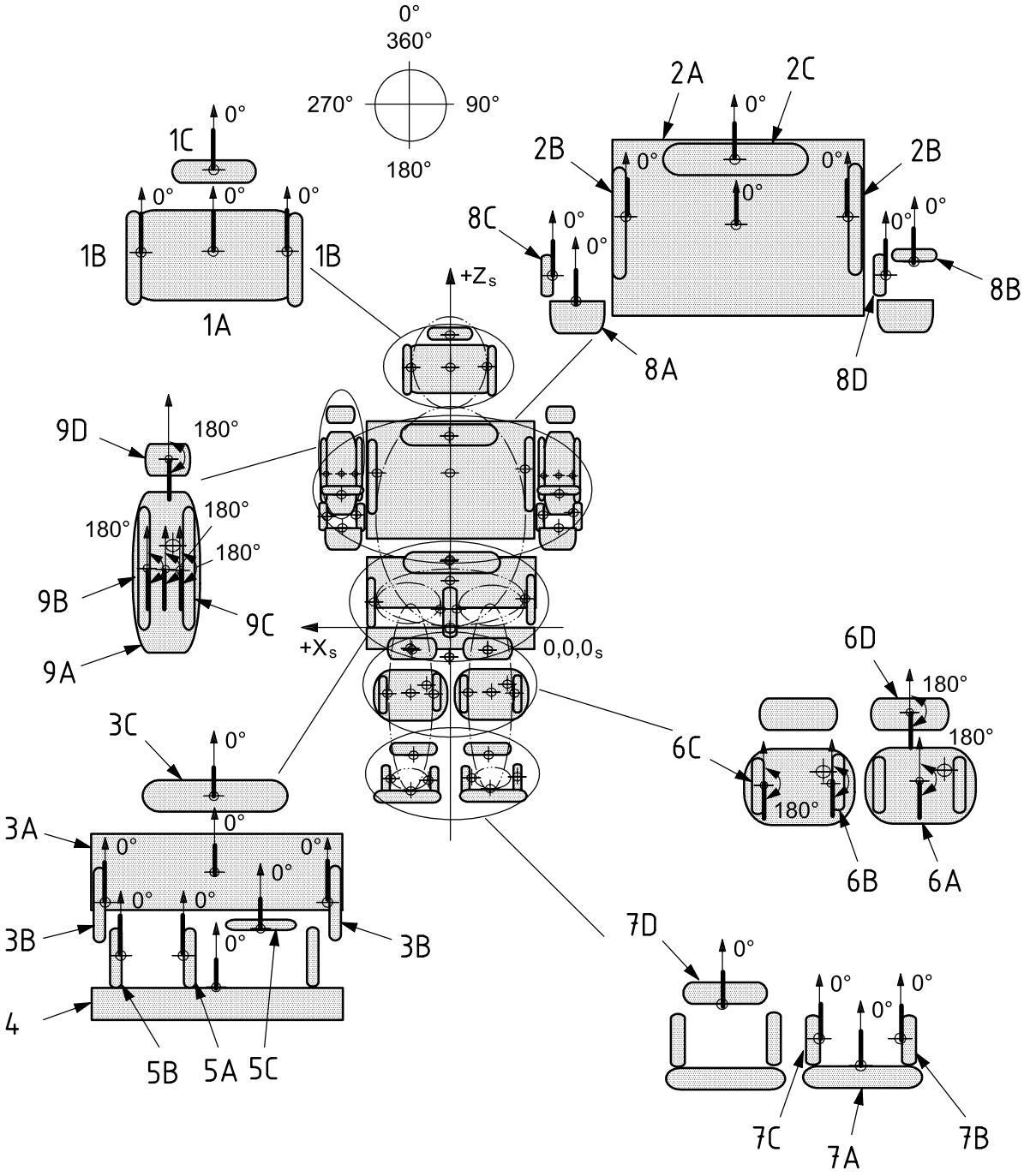
Figure A.1 — Illustrations of the orientation of reference lines of typical support surfaces as viewed in the sagittal plane

A.2.3 Frontal reference lines

Table A.2 — Orientation of support surface reference lines in the frontal SSRP

Support surface	Supported body segment	Absolute angle in SSRP	Range of typical values degrees	Figure A.2 reference
Posterior head	Head	0	340 to 20	1A
Lateral head	Head	0	340 to 20	1B
Anterior head	Head	0	340 to 20	1C
Back	Trunk	0	330 to 30	2A
Lateral trunk	Trunk	0	330 to 30	2B
Anterior trunk	Trunk	0	315 to 45	2C
Posterior pelvic	Pelvis	0	330 to 30	3A
Lateral pelvic	Pelvis	0	330 to 30	3B
Anterior pelvic	Pelvis	0	330 to 30	3C
Seat	Pelvis/thigh	0	330 to 30	4
Medial thigh	Thigh	0	330 to 30	5A
Lateral thigh	Thigh	0	330 to 30	5B
Superior thigh	Thigh	0	330 to 30	5C
Posterior leg	Leg	180	150 to 210	6A
Medial leg	Leg	180	150 to 210	6B
Lateral leg	Leg	180	150 to 210	6C
Anterior leg	Leg/knee	180	150 to 210	6D
Inferior foot	Foot	0	330 to 30	7A
Lateral foot	Foot	0	330 to 30	7B
Medial foot	Foot	0	330 to 30	7C
Superior foot	Foot	0	330 to 30	7D
Inferior forearm	Forearm	0	330 to 30	8A
Superior forearm	Forearm	0	330 to 30	8B
Lateral forearm	Forearm	0	330 to 30	8C
Medial forearm	Forearm	0	330 to 30	8D
Posterior arm	Arm	180	150 to 210	9A
Lateral arm	Arm	180	150 to 210	9B
Medial arm	Arm	180	150 to 210	9C
Anterior arm	Arm	180	150 to 210	9D

NOTE All values are in degrees using the 360° measurement method defined in 5.2.3. All frontal absolute angles are referenced to the +Z axis.



Key

1A	posterior head	4	seat	7A	inferior foot	9A	posterior arm
1B	lateral head	5A	medial thigh	7B	lateral foot	9B	lateral arm
1C	anterior head	5B	lateral thigh	7C	medial foot	9C	medial arm
2A	back	5C	superior thigh	7D	superior foot	9D	anterior arm
2B	lateral trunk	6A	posterior leg	8A	inferior forearm		
2C	anterior trunk	6B	medial leg	8B	superior forearm		
3A	posterior pelvis	6C	lateral leg	8C	lateral forearm		
3B	lateral pelvis	6D	anterior leg	8D	medial forearm		
3C	anterior pelvis						

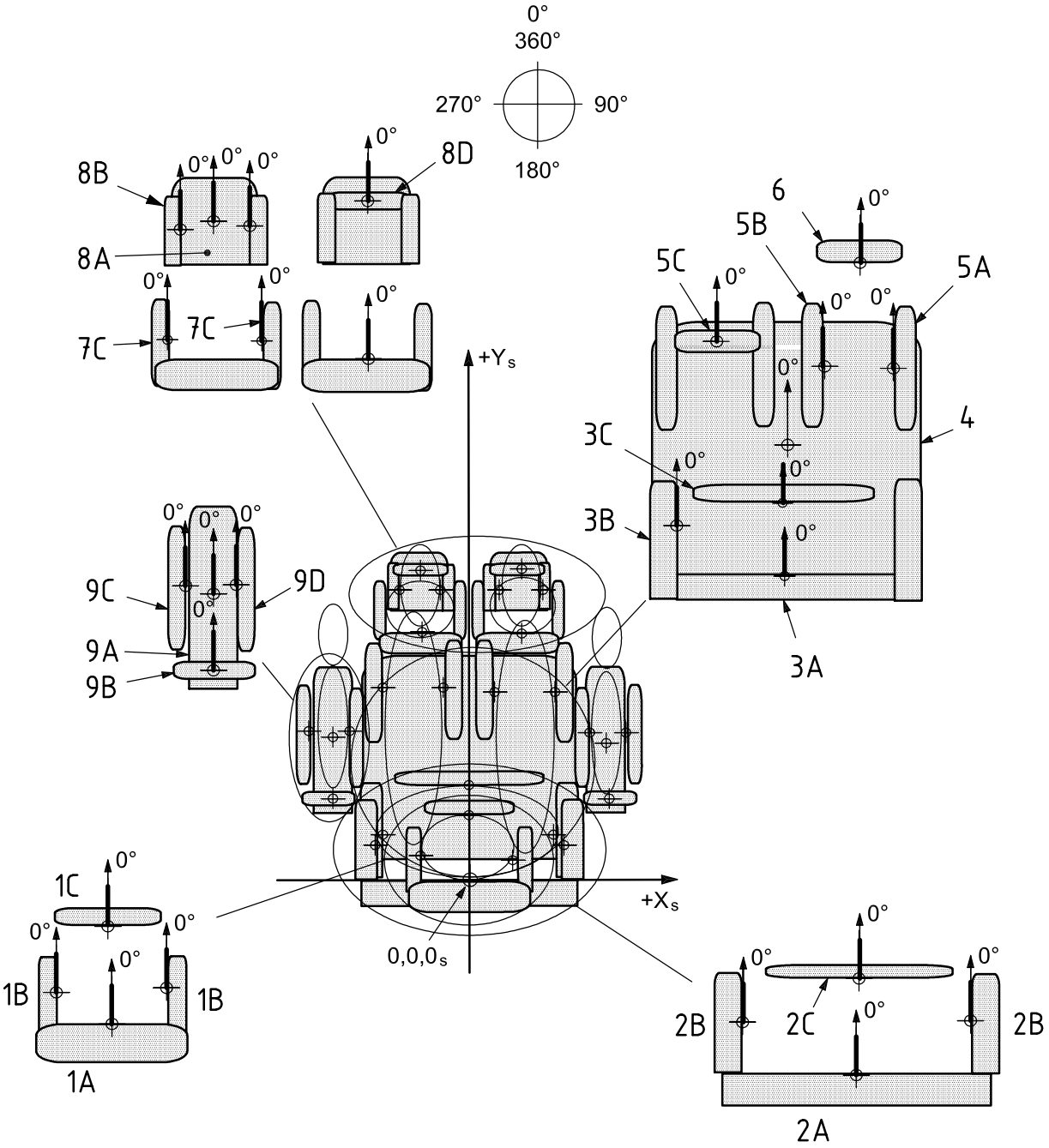
Figure A.2 — Illustrations of the orientation of reference lines of typical support surfaces as viewed in the frontal plane

A.2.4 Transverse reference lines

Table A.3 — Orientation of support surface reference lines in the transverse SSRP

Seat support surface	Supported body segment	Absolute angle in SSRP degrees	Range of typical values degrees	Figure A.3 reference
Posterior head	Head	0	315 to 45	1A
Lateral head	Head	0	315 to 45	1B
Anterior head	Head	0	315 to 45	1C
Back support	Trunk	0	315 to 45	2A
Lateral trunk	Trunk	0	315 to 45	2B
Anterior trunk	Trunk	0	45 to 135	2C
Posterior pelvic	Pelvis	0	315 to 45	3A
Lateral pelvic	Pelvis	0	315 to 45	3B
Anterior pelvic	Pelvis	0	315 to 45	3C
Seat support	Pelvis/thigh	0	315 to 45	4
Lateral thigh	Thigh	0	315 to 45	5A
Medial thigh	Thigh	0	315 to 45	5B
Superior thigh	Thigh	0	315 to 45	5C
Anterior leg	Leg/knee	0	315 to 45	6
Posterior leg	Leg	0	315 to 45	7A
Medial leg	Leg	0	315 to 45	7B
Lateral leg	Leg	0	315 to 45	7C
Inferior foot	Foot	0	315 to 45	8A
Lateral foot	Foot	0	315 to 45	8B
Medial foot	Foot	0	315 to 45	8C
Superior foot	Foot	0	315 to 45	8D
Inferior forearm	Forearm	0	270 to 90	9A
Superior forearm	Forearm	0	270 to 90	9B
Lateral forearm	Forearm	0	270 to 90	9C
Medial forearm	Forearm	0	270 to 90	9D

NOTE All values are in degrees using the 360° measurement method defined in 5.2.3. All transverse absolute angles are referenced to the +Y axis.



Key

1A	posterior head	4	seat	8A	inferior foot
1B	lateral head	5A	lateral thigh	8B	lateral foot
1C	anterior head	5B	medial thigh	8C	medial foot
2A	back	6	anterior thigh	8D	superior foot
2B	lateral trunk	7A	posterior leg	9A	inferior forearm
2C	anterior trunk	7B	medial leg	9B	superior forearm
3A	posterior pelvis	7C	lateral leg	9C	lateral forearm
3B	lateral pelvis			9D	medial forearm
3C	anterior pelvis				

Figure A.3 — Illustrations of the orientation of reference lines of typical support surfaces as viewed in the transverse plane

Annex B
(normative)

Calculations of joint centres

B.1 General principles

Determination of definitions for the spatial orientation of body segments is dependent on reliably identifying anatomical locations on the body (body landmarks) that can be used to identify the location of end points of body segment lines. The segment lines are then used to represent the spatial orientations of body segments in space. Most landmarks are known bony anatomical protuberances that can be readily located from palpation of the body surface. These landmarks not only identify the end points for the body segment lines, but also, in most cases, simulate the centre of rotation about which angular deviation of the body segment takes place. However, there are several key centres of rotation that cannot be readily located from palpation of the body surface. These are:

— hip joint centre,

— shoulder centre, and

— upper and lower neck joint centres.

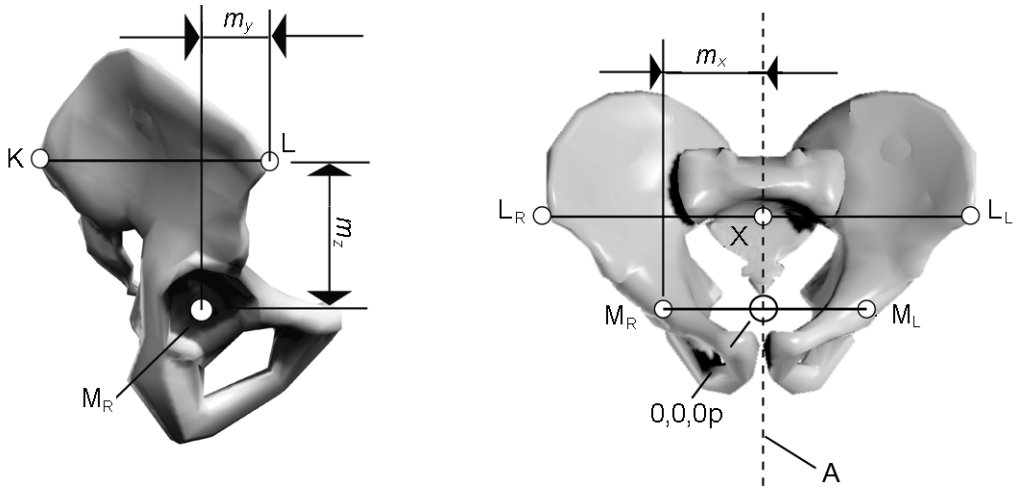
Research investigations, primarily done in automobile crash safety studies related to anthropometric dummy design, have provided verified data that allow the calculation of the above joint centre locations based on anatomical landmarks that can be readily located by palpation of the body surface. This annex provides formulae by which the difficult to locate joint centres can be calculated when improved accuracy is desired.

B.2 Hip joint

The greater trochanter is the surface landmark most often used clinically to locate the hip joint centre in the sagittal plane. However, the greater trochanter may or may not lie on the axis of the hip joint centre, since the hip joint is a ball and socket joint. As a result any significant degree of internal or external thigh rotation or hip abduction/adduction will introduce varying degrees of inaccuracy to the hip centre determination. Scaling factors have been derived from laboratory measures of the pelvis that allow the more accurate calculation of the hip centre in both the frontal and sagittal planes based on either of two common pelvic measures:

— ASIS to PSIS distance, or ASIS to ASIS distance.

— Table B.1 and Figure B.1 provide the scaling factors used to make these calculations based on the ASIS to ASIS distance.



Key

m_y	rearward distance parallel to K-L from point L to hip centre (M)	X	midpoint between the left and right ASISs
m_z	perpendicular downward distance from line K-L to the hip centre (M)	M_L	hip joint centre, left side
K	posterior superior iliac spine	m_x	perpendicular distance from the midsagittal plane to hip centre
L	anterior superior iliac spine (ASIS)	L_R-L_L	measured distance between left and right ASISs
M_R	hip joint centre, right side	A	midsagittal plane of the body

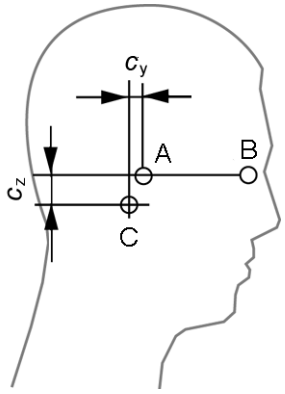
Figure B.1 — Hip joint centre coordinates

Table B.1 — Determination of the hip joint centre by calculation

Coordinate to be determined	Formula used for calculation	Approximate values for an average size male[a] mm
m_y	0,18 × (L_R-L_L distance)	42
m_z	0,29 × (L_R-L_L distance)	69
m_x	0,35 × (L_R-L_L distance)	83
NOTE ASIS-ASIS (L_R-L_L) distance in an average size male is 234 mm.		
[a] Taken from References [1] and [2].		

B.3 Upper neck joint

The upper neck joint corresponds anatomically to the atlanto-occipital joint, which is difficult to locate consistently from surface palpation. Figure B.2 and Table B.2 show the relationships for calculating the location of the upper neck joint using the eye corner (ectocanthus) and tragion.



Key

A tragion
B lateral eye corner
C upper neck centre point
c_y rearward distance, parallel to line A-B, from point A to point C
c_z downward distance, perpendicular to line A-B, from point A to point C

NOTE c_x is the perpendicular distance from the midsagittal plane to point C (in frontal view – not shown in figure).

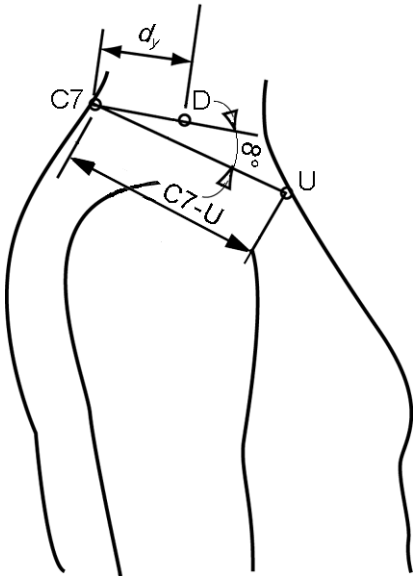
Figure B.2 — Sagittal upper neck joint

Table B.2 — Determination of the upper neck joint centre by calculation

Coordinate	Formula used for calculation	Approximate values for an average size male[a] mm
c_y	0,25 × (A-B)	−16
c_z	0,31 × (A-B)	−20
c_x	0 × (A-B)	0
NOTE 1 A-B = measured distance between points A and B. NOTE 2 Point C falls on the midsagittal plane of the head.		
[a] Taken from Reference [1].		

B.4 Lower neck joint

The lower neck joint corresponds anatomically to the C7/T1 joint, which is difficult to locate consistently from surface palpation. Figure B.3 and Table B.3 show the relationships for calculating the location of the lower neck joint using the most posterior point of the spinous process of C7 and the suprasternal notch.



Key

C7 spinous process of the C7 vertebra

U suprasternal notch

D lower neck centre point

d_y distance forward and downward from C7 along a line 8° above the C7-U segment line

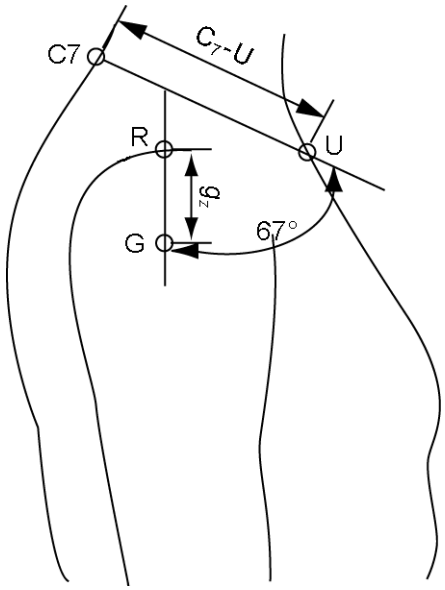
Figure B.3 — Sagittal lower neck joint

Table B.3 — Calculation of the lower neck joint centre

Coordinate	Formula used for calculation	Approximate value for an average size male[a] mm
d_y	0,55 × (C7-U)	76
NOTE C7-U = measured distance between points C7 and U. For an average size male, this distance is 188 mm.		
[a] Taken from References [5] and [6].		

B.5 Shoulder joint

The lateral tip of the acromion is a shoulder landmark that may be readily located. Laboratory measurements have determined that the centre of the shoulder (gleno-humeral) joint in the sagittal plane is located on a vertical line below the acromion, a distance of 42 % of the distance from the most posterior point of the spinous process of C7 to the suprasternal notch. Figure B.4 and Table B.4 define the relationships that allow a more accurate determination of the sagittal shoulder centre using these surface landmarks. An average value for adults for the distance g_z is 50 mm.



Key

C7 C7 vertebra spinous process

U suprasternal notch

R acromion point

G sagittal shoulder centre

g_z distance from R to G on a reference line 67° from C7-U (reference line is approximately vertical in the SRP position)

C7-U distance between C7 and supersternale

Figure B.4 — Shoulder joint centre

Table B.4 — Calculation of the shoulder joint centre

Coordinate	Calculation	Approximate value for an average size male[a] mm
g_z	0,42 × (C7-U)	50
NOTE C7-U = measured distance between points C7 and U. For an average size male this distance is 188 mm.		
[a] Taken from Reference [1].		

Annex C
(informative)

Abdominal and sternal body segment lines for use in sagittal and frontal body measures

C.1 General principles

Research has shown that sternal and abdominal lines may approximate the spinal alignment in sagittal and frontal planes[4]. This informative annex defines the segments that may be used to measure abdominal and sternal angles in these planes.

C.2 Terms and definitions of sternal and abdominal lines in the sagittal plane

C.2.1 Sternal and abdominal segments and segment lines in the sagittal plane

Tables C.1 and C.2 and Figure C.1 specify the sternal and abdominal segment lines.

Table C.1 — Terms and definitions of sternal and abdominal segments and lines in the sagittal plane

Segment line term and definition	Landmarks defining the segment line	See Figure C.1	Anatomical description of landmark
Sagittal sternum line line passing through the upper and lower sternal notch points	Upper sternal notch	U	Superior margin of the sternum (suprasternal notch)
	Lower sternal notch	V	Point at the inferior margin of the sternum (xiphoid process)
Sagittal abdominal line line passing through the lower sternal notch and the ASIS midpoint	Lower sternal notch	V	See above
	ASIS midpoint	X	Midpoint on a line between the left ASIS and the right ASIS

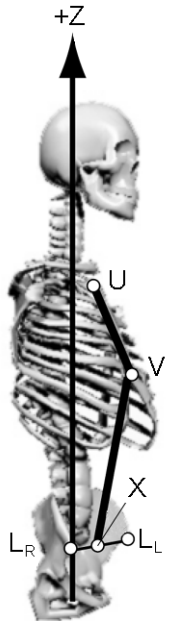


Figure C.1 — Abdominal and sternal body segment lines (torso view only)

Table C.2 — Orientation of sternal and abdominal segments lines in the sagittal SRP

Segment	Body segment line	Location of axis of rotation	Orientation to the +Z axis in the SRP[a] degrees
Sternum	V-U	V	351
Abdominal	X-V	X	7

[a] See Reference [7].

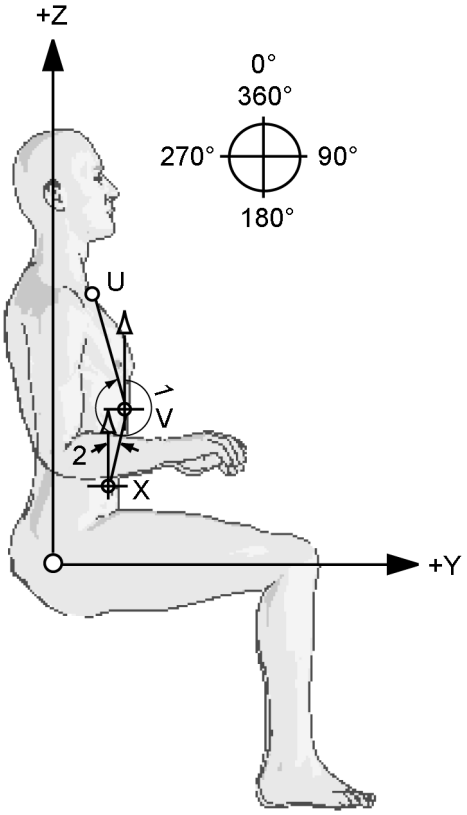
C.2.2 Absolute angles of sternal and abdominal segments in the sagittal plane

C.2.2.1
sagittal sternal angle
ST_{sang}
angular position of the sternal segment of the trunk defined by the angle between the vertical, +Z, axis and the sagittal sternal line

See item 1 in Figure C.2.

C.2.2.2
sagittal abdominal angle
AB_{sang}
angular position of the abdominal segment of the trunk defined by the angle between the vertical, +Z, axis and the sagittal abdominal line

See item 2 in Figure C.2.



Key

1 sagittal sternal angle

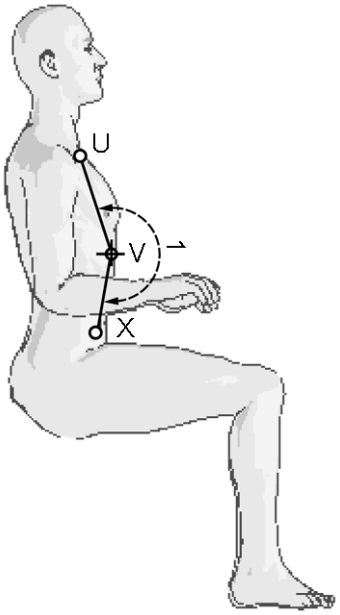
2 sagittal abdominal angle

Figure C.2 — Abdominal and sternal absolute angles in the sagittal view

C.2.3 Relative sternal to abdominal angle

C.2.3.1
sagittal sternum-to-abdominal angle
$(ST\text{-}AB)_{sang}$
angle formed between the sagittal sternum line and the sagittal abdominal line

See item 1 in Figure C.3.



Key

1 sagittal sternum-to-abdominal angle

Figure C.3 — Abdominal to sternal relative body angle in the sagittal view

C.3 Terms and definitions of abdominal lines in the frontal plane

C.3.1 Abdominal segment line in the frontal plane

Table C.3 — Terms and definitions of abdominal body segment in the frontal plane

Segment line term and definition	Landmarks defining the segment line	See Figure C.4	Anatomical description of landmark
Frontal abdominal line line passing through the lower sternal notch and the ASIS midpoint	Lower sternal notch	V	Point at inferior margin of sternum (xiphoid process)
	ASIS midpoint	X	Midpoint of the line between the right ASIS and left ASIS

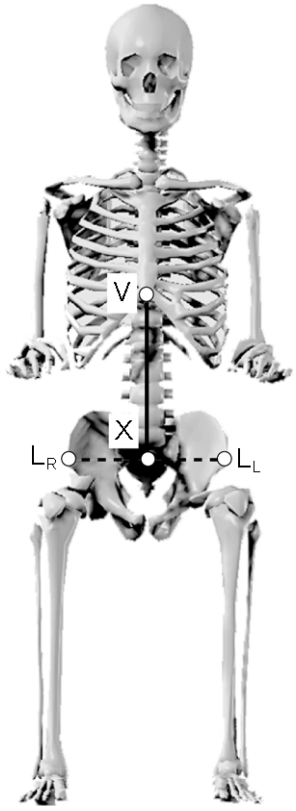


Figure C.4 — Abdominal body segment lines in the frontal view

Table C.4 — Orientation of abdominal segment in the frontal plane

Segment	Body segment line	Location of axis of rotation	Orientation to the +Z axis in the SRP degrees
Abdominal	X-V	X	0

C.3.2 Absolute frontal abdominal angle definition

C.3.2.1
frontal abdominal angle
AB_{fang}
angular position of the abdominal segment defined by the angle between the vertical axis, +Z, and the frontal abdominal line

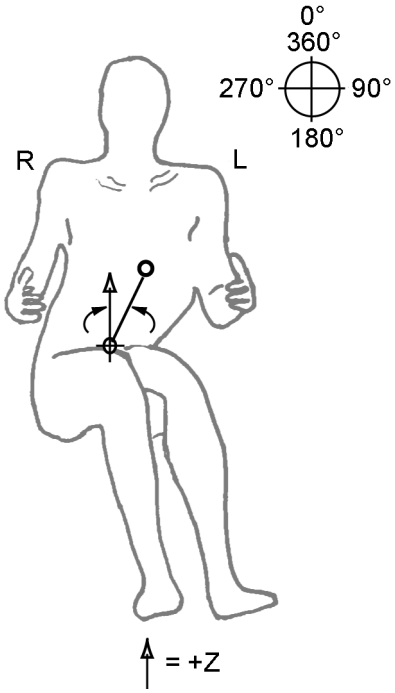


Figure C.5 — Frontal abdominal absolute angle

Bibliography

[1] REED, M. P. MANARY, M. A. and SCHNEIDER, L. W. *Methods for measuring and representing automobile occupant posture*. SAE Technical Paper series #1999-01-0959, 1999

[2] REYNOLDS, H. M.; SNOW, C. C.; and YOUNG, Y. W. S*patial geometry of the human pelvis*. Memorandum report No. AAC-119-81-5. Oklahoma City, OK: Civil Aeromedical Institute, Federal Aviation Administration 1981

[3] HOBSON, D. A., TOOMS, R. E. Seated lumbar/pelvic alignment: A comparison between spinal cord injured and noninjured groups. *Spine*, **17**(3), 1992, pp. 293-298

[4] HIROSE, H. *Sternum and abdominal line to describe the thoracic and lumbar spine*. Presentation at Annual RESNA Conference, June 28 – July 2, 2000, Orlando, FL

[5] SNYDER, R. G., CHAFFIN, D. B. and SCHUTZ, R. *Link system of the human torso.* Report No. AMRL-TR-71-88. Wright-Patterson Air Force Base, OH: Aerospace Medical Research Laboratory, 1972

[6] ROBBINS, D. H. *Anthropometric specifications for mid-sized male dummy.* Volume 2. Final report DOT-HS-806-716. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 1985a

[7] HIROSE, H. Reference inclinations of the sternal and abdominal line in the sitting posture. *Rehabilitation engineering*, **20**(2), 2005, p. 48-53, (Japanese)

[8] ISO 31 (all parts), *Quantities and units*

[9] ISO 690, *Documentation — Bibliographic references — Content, form and structure*

[10] ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*

[11] ISO 7176-5:1986, *Wheelchairs — Part 5: Determination of overall dimensions, mass and turning space*

[12] ISO 7176-7:1998, *Wheelchairs — Part 7: Measurement of seating and wheel dimensions*

[13] ISO 7250:1996, *Basic human body measurements for technological design*

[14] ISO/IEC TR 10000-1, *Information technology — Framework and taxonomy of International Standardized Profiles — Part 1: General principles and documentation framework*

[15] ISO 10241, *International terminology standards — Preparation and layout*

[16] IEC 60027 (all parts), *Letter symbols to be used in electrical technology*

[17] ISO/IEC Directives Part 2, *Rules for the structure and drafting of International Standards*, 2004

Alphabetical index

T

U

W

ICS 01.040.11; 11.180.10

Price based on 77 pages