

---

---

**Performance evaluation protocol for  
digital fitting systems —**

**Part 1:  
Accuracy of virtual human body  
representation**

*Protocole d'évaluation de la performance des systèmes d'habillage  
virtuel —*

*Partie 1: Fidélité de la représentation du corps humain virtuel*



—



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2021

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

# Contents

Page

<b>Foreword</b>	<b>iv</b>
<b>Introduction</b>	<b>v</b>
<b>1 Scope</b>	<b>1</b>
<b>2 Normative references</b>	<b>1</b>
<b>3 Terms and definitions</b>	<b>1</b>
<b>4 Basic requirements of virtual human modelling system</b>	<b>10</b>
4.1 General	10
4.2 Data import function	11
4.3 Data export function	11
4.4 Landmark extraction and export function	11
4.5 Function to take body dimensions data	11
4.6 Cross section creation function	11
4.7 Visualization function	11
4.8 Symmetrisation function	11
<b>5 Selection of subjects</b>	<b>11</b>
<b>6 Evaluation protocol for the virtual human body based on body dimensions</b>	<b>12</b>
6.1 General	12
6.2 Virtual body dimensions	12
6.3 Errors in body dimensions	13
<b>7 Cross sections and projection views</b>	<b>14</b>
7.1 General	14
7.2 Cross section	15
7.3 Superimposed display of torso cross sections	15
7.4 Dimensions of bounding rectangles of cross sections	15
7.5 Front, back and side views	16
<b>8 Report</b>	<b>16</b>
8.1 General	16
8.2 Information on the virtual human modelling system	16
8.3 Availability of the recommended functions	16
8.4 Information on subject population	17
8.5 Measurement errors	17
8.6 Cross sections and projection views	17
<b>Annex A (normative) Format for report: Evaluation of a virtual human modelling system</b>	<b>18</b>
<b>Annex B (informative) Example of report: Evaluation of a virtual human modelling system based on 3D body scan data</b>	<b>24</b>
<b>Annex C (informative) Example of report: Evaluation of a virtual human modelling system based on body dimension data</b>	<b>30</b>
<b>Annex D (informative) Example of report: Evaluation of a virtual human modelling system for virtual fit mannequin models</b>	<b>37</b>
<b>Annex E (informative) Format for report: Evaluation of a virtual fit mannequin</b>	<b>42</b>
<b>Bibliography</b>	<b>46</b>



## 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 133, *Clothing sizing systems - size designation, size measurement methods and digital fittings*.

A list of all parts in the ISO 20947 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).



## Introduction

Digital fitting systems are used for evaluating the fit of a garment without making physical patterns or physical garments. In a digital fitting system, a virtual garment is made using virtual patterns, and the fit of physical garment(s) on a physical human body is assessed by draping a virtual garment on a virtual human body or a virtual fit mannequin (fit form). Such systems are useful for designers and manufacturers, educationalists and retailers of garments because the system helps to improve the fit of garments and productivity. It can also be useful for consumers for assessing the fit of mass-produced garments, for online shopping or for selecting an appropriate size.

The digital fitting system enables examination of the fit of a garment by placing a virtual garment on a virtual human body. Greater accuracy in examining the fit of the virtual garment requires a virtual human body representing the human body accurately. There are several methods for creating the virtual human body. The most popular is the use of a 3D body scan data of a human body, scan data of a fit mannequin representing a specified human form and a parametric model created from body dimensions.

This document defines the virtual human body system that forms the basis of the digital fitting system. This document establishes not only the basic functional requirements of this system but also the protocol for assessing the quality of the virtual human body. The protocol is expected to enable users of digital fitting systems (designers, educationalists and retailers) to choose the virtual human body system most appropriate for their purposes and, at the same time, realize easier performance evaluation of digital fitting systems that make use of the virtual human body (including virtual fit mannequin) model. Since the accuracy of scan-derived measurements and surface shape depends on the accuracy of 3D body scanner system used, manual measurements are used for quantitatively evaluating the accuracy of a virtual human body. Accuracy of scan-derived measurements should be evaluated according to ISO 20685-1.

Copyright International Organization for Standardization



# Performance evaluation protocol for digital fitting systems —

## Part 1: Accuracy of virtual human body representation

### 1 Scope

This document focuses on the method of quantifying the differences in body dimensions and visualizing shape differences between the human body and a virtual human body model. This document provides a performance evaluation protocol for virtual human body representation systems, which create virtual human body (including virtual fit mannequin) models based on 3D body scan data and/or body dimensions data of a human body. The required accuracy of a virtual human body depends on the purpose and use of the digital fitting system.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8559-1, *Size designation of clothes — Part 1: Anthropometric definitions for body measurement*

ISO 18825-1, *Clothing — Digital fittings — Part 1: Vocabulary and terminology used for the virtual human body*

ISO 18825-2, *Clothing — Digital fittings — Part 2: Vocabulary and terminology used for attributes of the virtual human body*

ISO 20685-1, *3-D scanning methodologies for internationally compatible anthropometric databases — Part 1: Evaluation protocol for body dimensions extracted from 3-D body scans*

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

#### 3.1

##### **digital fitting system**

fitting system that provides qualitative and/or quantitative evaluations of overall and/or specific simulation garment fit through analysis of the distribution of surface strain, gap between body and garment, heat map, cross section, surface wrinkles, seam drop, garment balance, etc.

#### 3.2

##### **virtual human modelling system**

system for creating a *virtual human body* (3.3.2) for a specific market or individual

Note 1 to entry: Asymmetrical shape assumed to match the body shape of the individual.



### 3.3 virtual human model

three-dimensional model in digital format

[SOURCE: ISO 18825-1: 2016, 2.1.1]

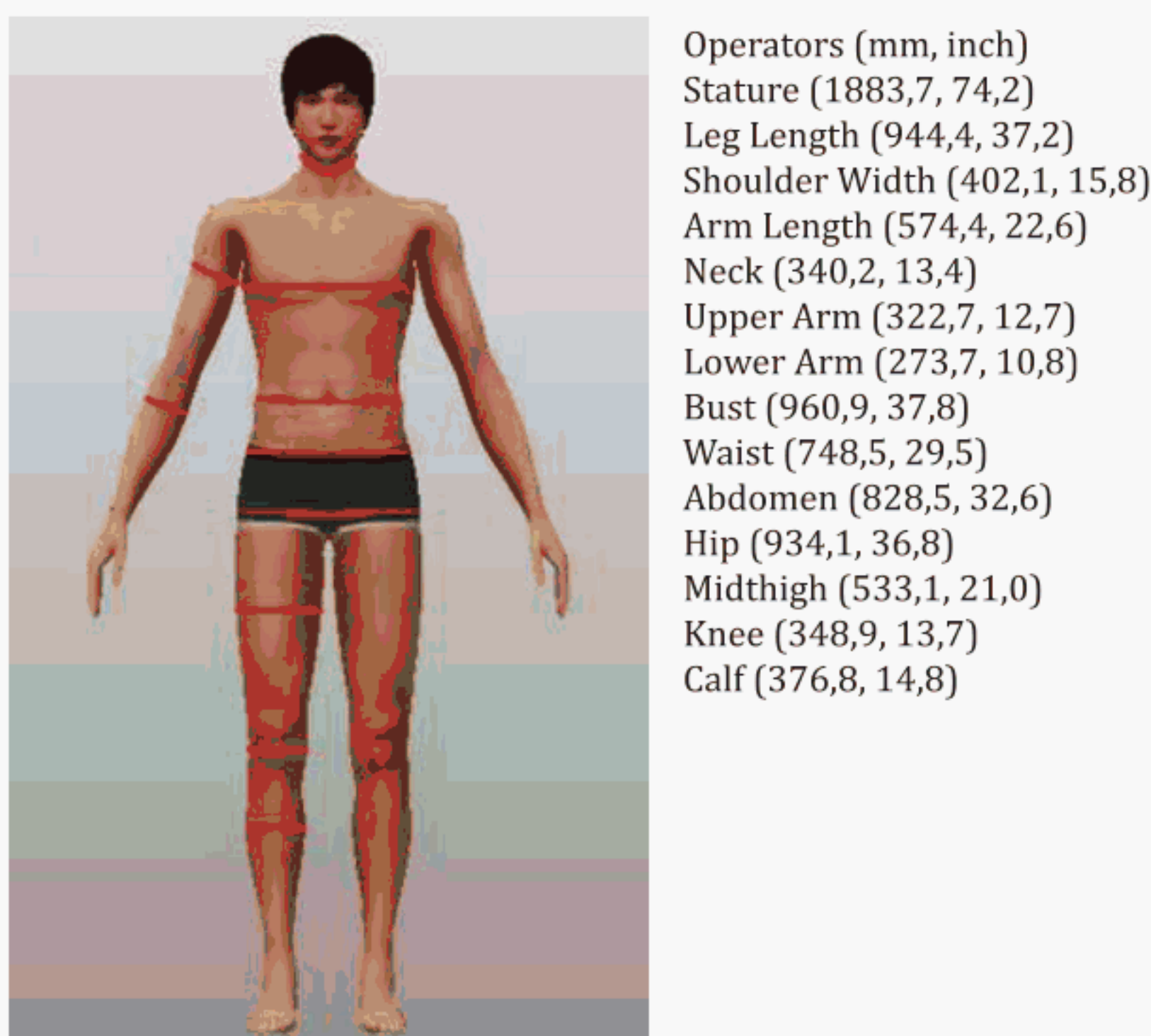
#### 3.3.1 parametric human body

*virtual human model* (3.3) with changeable parameters such as size and shape, etc.

Note 1 to entry: Parametric human body is created by modifying the parameters of the exemplar model imported from the 3D model library. The exemplar models vary by country as they are based on a database. Therefore, a parametric human body can be made on the basis of height variations, BMI (body mass index) and so on.

Note 2 to entry: The parameters of the parametric human body are presented in the parametric human body software. The parameters of the parametric human body can be added depending on the purpose of users.

Note 3 to entry: to entry See [Figure 1](#).



**Figure 1 — Examples of parameters of a male adult body**

[SOURCE: ISO 18825-1: 2016, 2.1.1.1]

#### 3.3.2 virtual human body

*virtual clone* (3.3.2.1) for digital fitting in the apparel industry, including information such as size, shape, cross section, body texture and skeletal structure

Note 1 to entry: Also called “fashion avatar”. In computing, an avatar is the graphical representation of the user or the user’s alter ego or character.

Note 2 to entry: The virtual human body is classified into two key types: virtual clone and virtual twin.

Note 3 to entry: In this document, virtual human body includes at least virtual clone, virtual twin and virtual fit mannequin model.

[SOURCE: ISO 18825-1: 2016, 2.1.1.2, modified — Note 3 to entry has been added.]



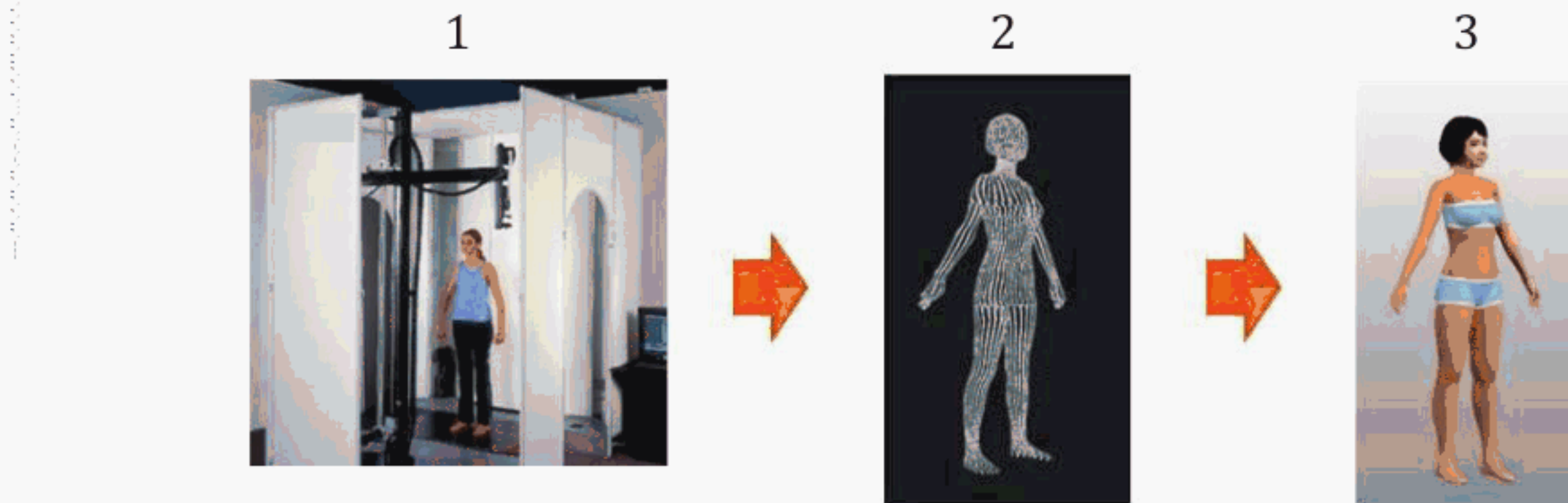
**3.3.2.1****virtual clone****virtual shape**

*virtual human body* (3.3.2) that is created by forming three-dimensional surface data from a 3D body scanned, using surface modelling processes including noise elimination, hole-filling and mesh generation

Note 1 to entry: It is essential that a user be scanned first to create a virtual clone.

Note 2 to entry: The virtual clone is identical to the body shape of the user.

Note 3 to entry: See [Figure 2](#).

**Key**

- 1 3D scanning
- 2 3D scanned point cloud
- 3 virtual clone

**Figure 2 — Process of creating a virtual clone**

[SOURCE: ISO 18825-1: 2016, 2.1.1.2.1]

**3.3.2.2****virtual twin****virtual size**

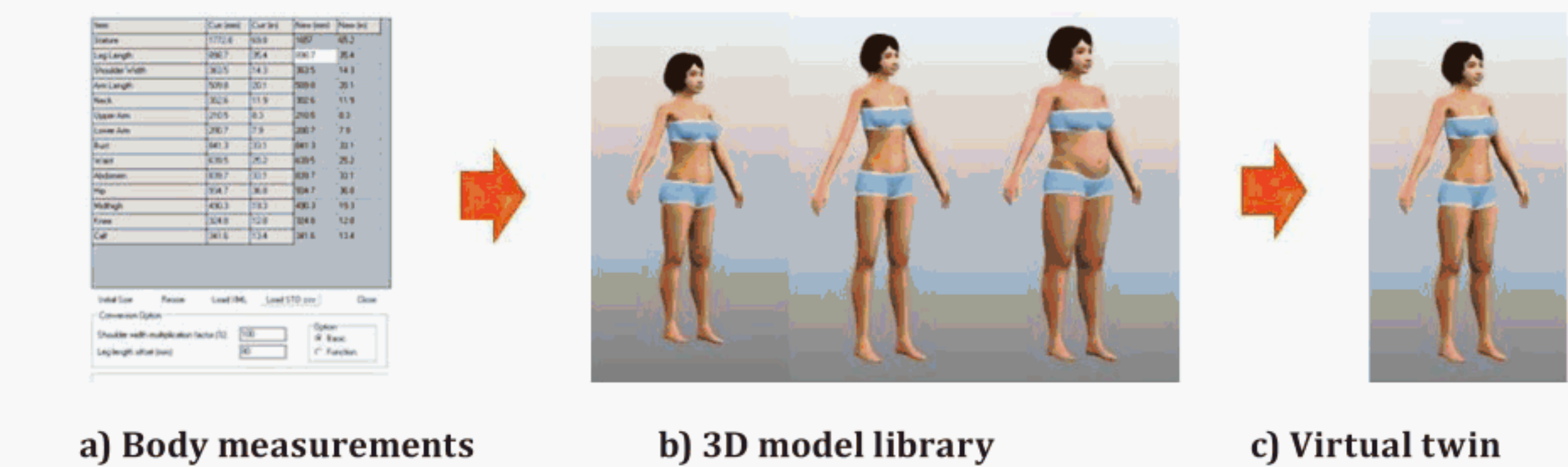
*virtual human body* (3.3.2) morphed according to body dimensions acquired either through manual or automatic measurements

Note 1 to entry: The virtual twin is a *parametric human body* (3.3.1) as it can be altered with parameters.

Note 2 to entry: The virtual twin is not identical to the user; but is a close approximation that can be altered by entering parameters retrieved from a population database.

Note 3 to entry: See [Figure 3](#).

Note 4 to entry: A virtual twin can be created directly from the person being scanned or as in case of most digital systems from an existing library.



NOTE Body measurements are necessary to create a virtual twin.

Figure 3 — Process of creating a virtual twin

[SOURCE: ISO 18825-1: 2016, 2.1.1.2.2, modified — “that is applied” has been replaced by “according to” and Note 4 to entry has been added.]

3.3.2.3  
virtual fit mannequin

virtual human body (3.3.2) that represents an actual human body model in digital format used for garment visualization

Note 1 to entry: The model is used for draping simulation (3D form and design realization for example) and examining silhouette and fit of a garment.

Note 2 to entry: See Figure 4.

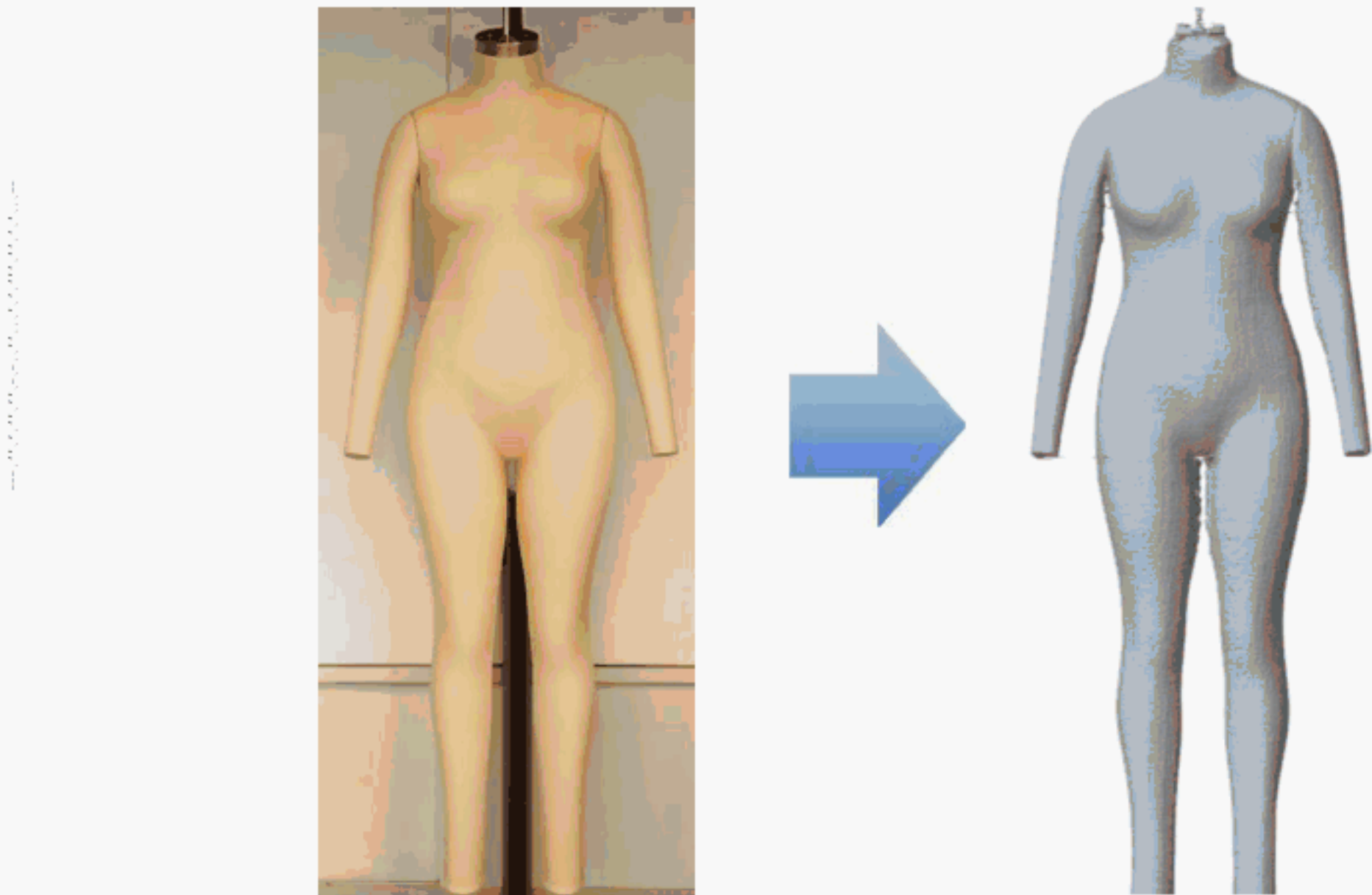


Figure 4 — Process of creating a virtual fit mannequin



### 3.4

#### virtual standing position

posture of a *virtual human model* (3.3) used for measuring dimensions and fit

Note 1 to entry: In a virtual standing position, the head is in the Frankfurt plane, the long axes of the feet should be parallel to one another and 200 mm apart. The upper arms are abducted to form a 20° angle with the sides of the torso and the elbows are straight. But the palms face toward the torso. This position shall be used for evaluating the fit of garments.

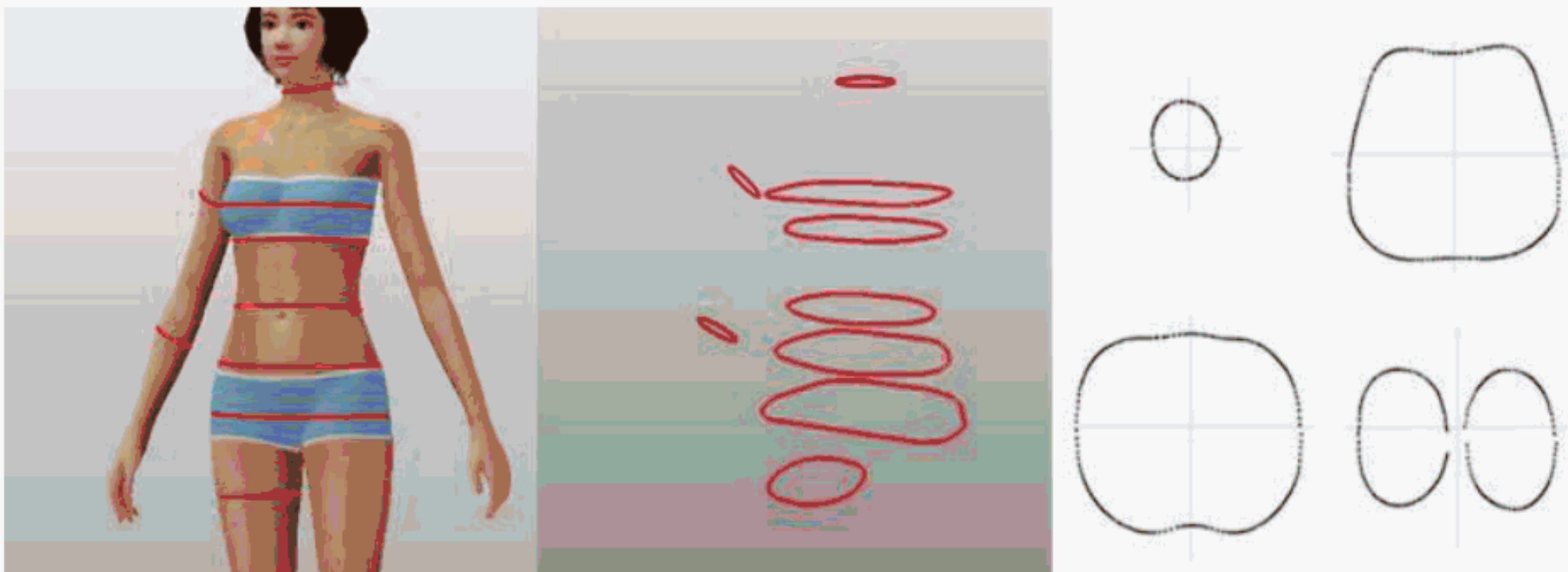
### 3.5

#### virtual cross section

closed contour extracted from the plane cutting a virtual body segment perpendicular to its main axis or the three principle axes

Note 1 to entry: See [Figure 5](#).

Note 2 to entry: The main axis is the axis that connects the joints on either side of the virtual body segment.



**Figure 5 — Examples of virtual body cross sections**

[SOURCE: ISO 18825-1: 2016, 2.2.2]

### 3.6

#### virtual body landmarks and levels

points that define the characteristic of the body shape of the user in the *virtual standing position* (3.4)

Note 1 to entry: For example, points of bone prominence, peak points on a convex or concave surface, or points like the bust point can be virtual body landmarks.

Note 2 to entry: On a physical body, a virtual fit mannequin or a physical fit mannequin, the landmarks and the levels are defined in the same manner.

Note 3 to entry: Some of the landmarks are evaluated in terms of their levels in this document (see [Table 1](#)).

Note 4 to entry: When a physical body or a physical fit mannequin is 3D scanned, markers for the landmarks can be put on it to extract their positions.

[SOURCE: ISO 18825-1:2016, 2.2.4]



**Table 1 — Virtual and physical body landmark points and levels**

No.	Virtual body landmark points	Male/Female
1	Virtual back neck-base point	both
2	Virtual shoulder point (Right and Left)	both
3	Virtual axilla point	male
4	Virtual bust point	female
5	Virtual underbust point	female
6	Virtual midriff level	female
7	Virtual side waist point (Right and Left)	both
8	Virtual back waist point	both
9	Virtual top hip level	both
10	Virtual hip point	both
11	Virtual crotch point	both
12	Virtual gluteal fold point	both
13	Virtual elbow point (Right and Left)	both
14	Virtual wrist point (Right and Left)	both
15	Virtual side neck-base point (Right and Left)	both
16	Virtual landing heel point	both

**3.6.1****virtual back neck-base point**

most posterior point at the back neck-base on the midsagittal plane with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.1.5]

**3.6.2****virtual shoulder point**

most lateral point of the shoulder ridge line passing through the cross section covering the middle plane of the torso and arm with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.1.6]

**3.6.3****virtual axilla point**

lowest point under the axillary passing through the cross section between the torso and arm with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.1.7]

**3.6.4****virtual bust point**

most anterior point of the bust with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

Note 1 to entry: This point is used for a female.

[SOURCE: ISO 18825-2:2016, 2.1.10, modified — Note 1 to entry modified.]

**3.6.5****virtual underbust point**

lowest point or its level under the bust projection with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

Note 1 to entry: This point is used for a female.



[SOURCE: ISO 18825-2:2016, 2.1.11, modified — "or its level" has been added, Note 1 to entry has been modified.]

### 3.6.6

#### **virtual midriff level**

midway between the levels of the virtual underbust point and virtual side waist point

Note 1 to entry: This level is used for a female.

Note 2 to entry: [SOURCE: ISO 8559-1:2017, 3.1.21, modified — Term and definition modified to apply to the virtual human body, Note 1 to entry modified.]

### 3.6.7

#### **virtual side waist point**

most concave point or its level of the (right) side waist when viewed from the front with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.1.12]

### 3.6.8

#### **virtual back waist point**

point of the back waist on the midsagittal plane at the level of the *virtual side waist point* (3.6.7) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.1.13]

### 3.6.9

#### **virtual top hip level**

midway between the level of the virtual side waist point and virtual side hip point

[SOURCE: ISO 8559-1:2017, 3.1.24, modified — Term and definition modified to apply to the virtual human body.]

### 3.6.10

#### **virtual hip point**

most posterior point of the hip when viewed from the front when the *virtual human body* (3.3.2) is in a *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.1.15, modified — "when viewed from the front" has been added.]

### 3.6.11

#### **virtual crotch point**

lowest point of the torso on the midsagittal plane with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.1.16]

### 3.6.12

#### **virtual gluteal fold point**

most concave point on the sagittal plane passing through the *virtual hip point* (3.6.10) between hip and thigh or its level with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.1.20]

### 3.6.13

#### **virtual elbow point**

most protruding point of the elbow

[SOURCE: ISO 18825-2:2016, 2.1.17]



### 3.6.14

#### **virtual wrist point**

most concave point of the extended line of the little finger passing through the cross section between the arm and hand with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.1.18]

### 3.6.15

#### **virtual side neck-base point**

intersection point of the concave contour line at the neck-base passing through the shoulder ridge line with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.1.4]

### 3.6.16

#### **virtual landing heel point**

lowest point or level of the posterior calcaneus with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

Note 1 to entry: The virtual landing heel point can reach the floor or the top of the shoe heel.

[SOURCE: ISO 18825-2:2016, 2.1.26, modified — "or level" has been added, Note 1 to entry has been modified.]

## 3.7

### **virtual body dimensions**

size information on virtual body segments of the *virtual human body* (3.3.2) that corresponds to measured anthropometric dimensions of the user in the *virtual standing position* (3.4)

Note 1 to entry: See 6.2.

### 3.7.1

#### **virtual chest girth**

horizontal girth of the torso passing through the *virtual axilla point* (3.6.3) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.17]

### 3.7.2

#### **virtual bust girth**

horizontal girth of the torso passing through the *virtual bust point* (3.6.4) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.18]

### 3.7.3

#### **virtual underbust girth**

horizontal girth of the torso passing through the *virtual underbust point* (3.6.5) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.19]

### 3.7.4

#### **virtual waist girth**

horizontal girth of the torso passing through the *virtual side waist point* (3.6.7) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.20]



**3.7.5****virtual hip girth**

horizontal girth of the torso passing through the *virtual hip point* (3.6.10) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.22]

**3.7.6****virtual thigh girth**

horizontal girth of the leg at the level of *virtual gluteal fold point* (3.6.12) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.23, modified — "virtual crotch point" has been changed to "virtual gluteal fold point".]

**3.7.7****virtual chest height**

vertical distance between the *virtual landing heel point* (3.6.16) and *virtual axilla point* (3.6.3) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

**3.7.8****virtual bust height**

vertical distance between the *virtual landing heel point* (3.6.16) and *virtual bust point* (3.6.4) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.2]

**3.7.9****virtual underbust height**

vertical distance between the *virtual landing heel point* (3.6.16) and *virtual underbust point* (3.6.5) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

**3.7.10****virtual waist height**

vertical distance between the *virtual landing heel point* (3.6.16) and *virtual side waist point* (3.6.7) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.3]

**3.7.11****virtual hip height**

vertical distance between the *virtual landing heel point* (3.6.16) and *virtual hip point* (3.6.10) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4).

[SOURCE: ISO 18825-2:2016, 2.2.4]

**3.7.12****virtual thigh height**

vertical distance between the *virtual landing heel point* (3.6.16) and *virtual gluteal fold point* (3.6.12) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

**3.7.13****virtual arm length**

sum of the distance of the straight line between *virtual shoulder point* (3.6.2) and *virtual elbow point* (3.6.13), and the distance of the straight line between *virtual elbow point* and *virtual wrist point* (3.6.14) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

Note 1 to entry: In case 'virtual arm length' is used to mean 'surface length', it should be marked that there has been a change in meaning.

Note 2 to entry: In this document virtual arm length is mainly used to mean surface length.



[SOURCE: ISO 18825-2:2016, 2.2.10, modified — Notes 1 and 2 to entry have been modified.]

### 3.7.14

#### **virtual upper arm girth**

maximum girth of the upper arm perpendicular to the main axis of the upper arm and passing through the *virtual axillia point* (3.6.3) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.14]

### 3.7.15

#### **virtual wrist girth**

girth of the forearm perpendicular to the main axis of the forearm and passing through the *virtual wrist point* (3.6.14) with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.16]

### 3.7.16

#### **virtual inside leg height**

vertical distance between the *virtual landing heel point* (3.6.16) and virtual crotch with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.5, modified — The term "virtual crotch height" has been deleted.]

### 3.7.17

#### **virtual centre back waist length**

surface distance between the virtual centre back neck-base point and the virtual centre back waist point with the *virtual human body* (3.3.2) in the *virtual standing position* (3.4)

[SOURCE: ISO 18825-2:2016, 2.2.9, modified — "Centre" was added to the term and to the definition.]

### 3.7.18

#### **virtual shoulder width**

horizontal distance between right and left *virtual shoulder points* (3.6.2)

Note 1 to entry: In case 'virtual shoulder width' is used to refer to 'surface length', it should be marked that there has been a change in meaning.

[SOURCE: ISO 18825-2:2016, 2.2.8]

### 3.7.19

#### **virtual shoulder slope**

values, in degrees, of the angles of inclination of a line joining the (virtual) shoulder point and the (virtual) side neck-base point against the horizontal plane

Note 1 to entry: The difference (in mm) between levels of the (virtual) shoulder point and the (virtual) side neck-base point may be used (see ISO 8559-1:2017, Figure 115).

### 3.7.20

#### **virtual shoulder length**

surface distance between a *virtual shoulder point* (3.6.2) and a *virtual side neck-base point* (3.6.15) in the right and left side of a *virtual human body* (3.3.2)

## **4 Basic requirements of virtual human modelling system**

### **4.1 General**

The virtual human modelling system shall have the following functions.



## 4.2 Data import function

The system shall have the function to import body surface shape data and/or body dimensions data of any human body. It is recommended that the system is able to import the location of landmarks.

## 4.3 Data export function

The system shall have the functionality to export a virtual human body in a format, which is available to digital fitting systems, such as Wavefront .obj format. Namely, the virtual human body is a closed polyhedron consisting of triangular elements without self-intersections, and the two sides of each triangle are consistent for the entire body. The order is fixed for the three vertices of each triangle, and the side appearing to be counter clockwise in direction is defined as an exterior side.

## 4.4 Landmark extraction and export function

The system shall have the functionality to extract the virtual body landmarks and levels when they are not imported. The system should have the functionality to export the landmarks and levels listed in [Table 1](#) on the virtual human body.

## 4.5 Function to take body dimensions data

The system shall have the functionality to measure body dimensions listed in [Table 2](#) on the virtual human body in accordance with ISO 18825-2 or ISO 8559-1. For a virtual fit mannequin model, the system shall have the function to measure body dimensions corresponding to those of a human body if the virtual fit mannequin model has the landmarks to define the dimensions.

## 4.6 Cross section creation function

The system shall have the function to create the virtual cross sections listed in [Table 3](#) on the virtual human body in accordance with ISO 18825-2. The system also shall have the function to create cross sections of the imported human body data. For a virtual fit mannequin model, the system shall have the function to create cross sections of the virtual fit mannequin model corresponding to virtual cross sections of a virtual shape.

The system shall have the function to create the virtual bounding rectangles of the cross sections. The virtual bounding rectangle is the minimum rectangle containing the cross section, and whose edges are in the lateral or anteroposterior direction.

## 4.7 Visualization function

The system shall have the function to visualize the virtual human body in 3D form. Additionally, the system should be able to show the specified body dimensions and cross section positions over the model.

## 4.8 Symmetrisation function

The system should have the function to create a symmetrical virtual human body even if the imported 3D body scan data is asymmetrical.

# 5 Selection of subjects

Subjects shall reflect approximately the same range of body sizes and shape variations expected in the population for which the virtual human body system is intended. The subjects shall also include a variety of body types — not just people of average height and weight. If children are included in the intended population, it is particularly important that the subjects cover the age range of the intended population.

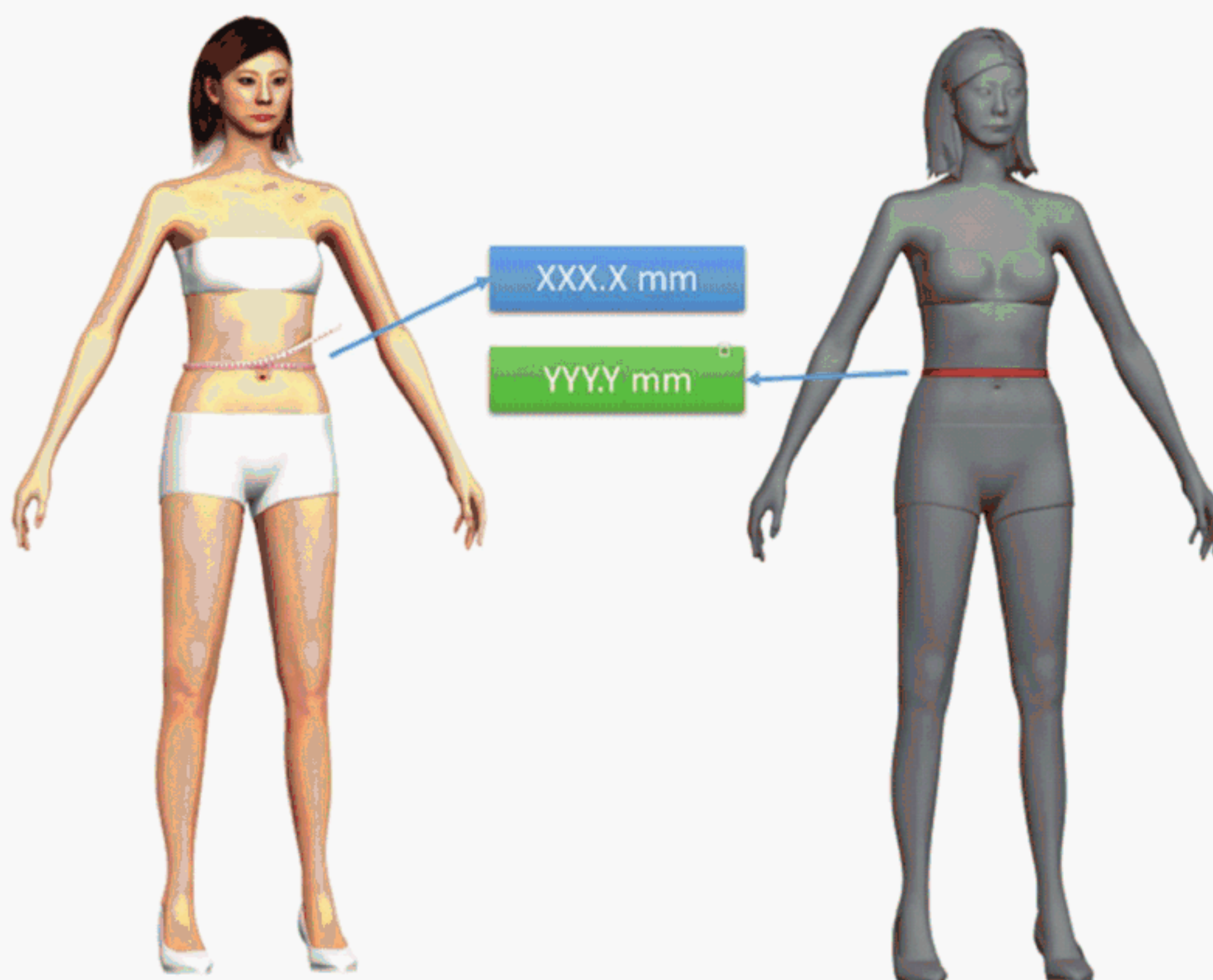


At least three persons shall be selected for men and for women, including three levels representing the distribution (near the 5th percentile, near the average, and near the 95th percentile) in height, and bust or chest girth. Nine persons should be selected including combinations of the 3 levels in each of height, and bust or chest girth. In case of virtual fit mannequins, the subjects of at least three sizes also shall be selected according to the distribution in height and bust or chest girth of the intended population.

## 6 Evaluation protocol for the virtual human body based on body dimensions

### 6.1 General

The accuracy of the virtual human body in representing the body dimensions of a specific human body is quantified with the following method (see [Figure 6](#)). Particularly a virtual clone and a virtual fit mannequin model are evaluated with the method. In addition, when the accuracy of a virtual fit mannequin to a physical fit mannequin is evaluated, the method is also applicable when substituting a human body with a physical fit mannequin. On the other hand, a virtual size and a virtual fit mannequin (scanned human data) shall be compared without dimensions but only using the cross sections as described in [Clause 7](#) since these virtual models are generated from body dimensions.



**Figure 6 — Evaluation with body dimensions**  
(left: physical human body, right: virtual human body)

### 6.2 Virtual body dimensions

The body dimensions shown in [Table 2](#) shall be acquired for both the human body and the virtual human body for each of the selected subjects. In case of evaluation for a virtual clone, both of left and right sides should be measured for the thigh girths, the arm lengths, the upper arm girths, the wrist girths, the shoulder slopes and the shoulder lengths. For virtual twin or virtual fit mannequin, which



may be treated as symmetrical, one of a left or right side is measured. If necessary, evaluation of items other than those shown in [Table 2](#) may be added. Most of them are defined in ISO 18825-2, but virtual chest height, Virtual underbust height, Virtual thigh height, Virtual shoulder slope and Virtual shoulder length are newly defined below. The girths for the virtual human body shall be measured, assuming a tape measure is used, measuring the circumference and not the contours.

Human body dimensions shall be measured in accordance with ISO 8559-1. Measurement values of the virtual human body shall be acquired in the virtual standing position as given in ISO 18825-1, using the measurement function of the virtual human modelling system. If generating the virtual human body from 3D body scan data, the body shall be measured in standing position A of ISO 20685-1.

In case of a virtual human body without its feet or legs, the waist or hip height of a physical body and the virtual human body are assumed to be the same value and treated as a reference height.

**Table 2 — Body dimensions used in evaluation**

	Virtual body dimension	Requirement
1	Virtual chest girth	required for male
2	Virtual bust girth	required for female
3	Virtual underbust girth	required for female
4	Virtual waist girth	required
5	Virtual hip girth	required
6	Virtual thigh girth (right)	essential
7	Virtual thigh girth (left)	essential
8	Virtual chest height	required for male
9	Virtual bust height	required for female
10	Virtual underbust height	required for female
11	Virtual waist height	required
12	Virtual hip height	required
13	Virtual thigh height (right)	essential
14	Virtual thigh height (left)	essential
15	Virtual arm length (right)	required
16	Virtual arm length (left)	required
17	Virtual upper arm girth (right)	required
18	Virtual upper arm girth (left)	required
19	Virtual wrist girth (right)	required
20	Virtual wrist girth (left)	required
21	Virtual inside leg height	required
22	Virtual centre back waist length	required
23	Virtual back neck point to waist	required
24	Virtual shoulder width	required
25	Virtual shoulder slope (right)	required
26	Virtual shoulder slope (left)	required
27	Virtual shoulder length (right)	required
28	Virtual shoulder length (left)	required

### 6.3 Errors in body dimensions

Error is calculated by subtracting human body dimension value from virtual human body dimension value (mm). For each item, the maximum, the minimum, the mean, and the standard deviation of the error, as well as the mean absolute error are calculated.

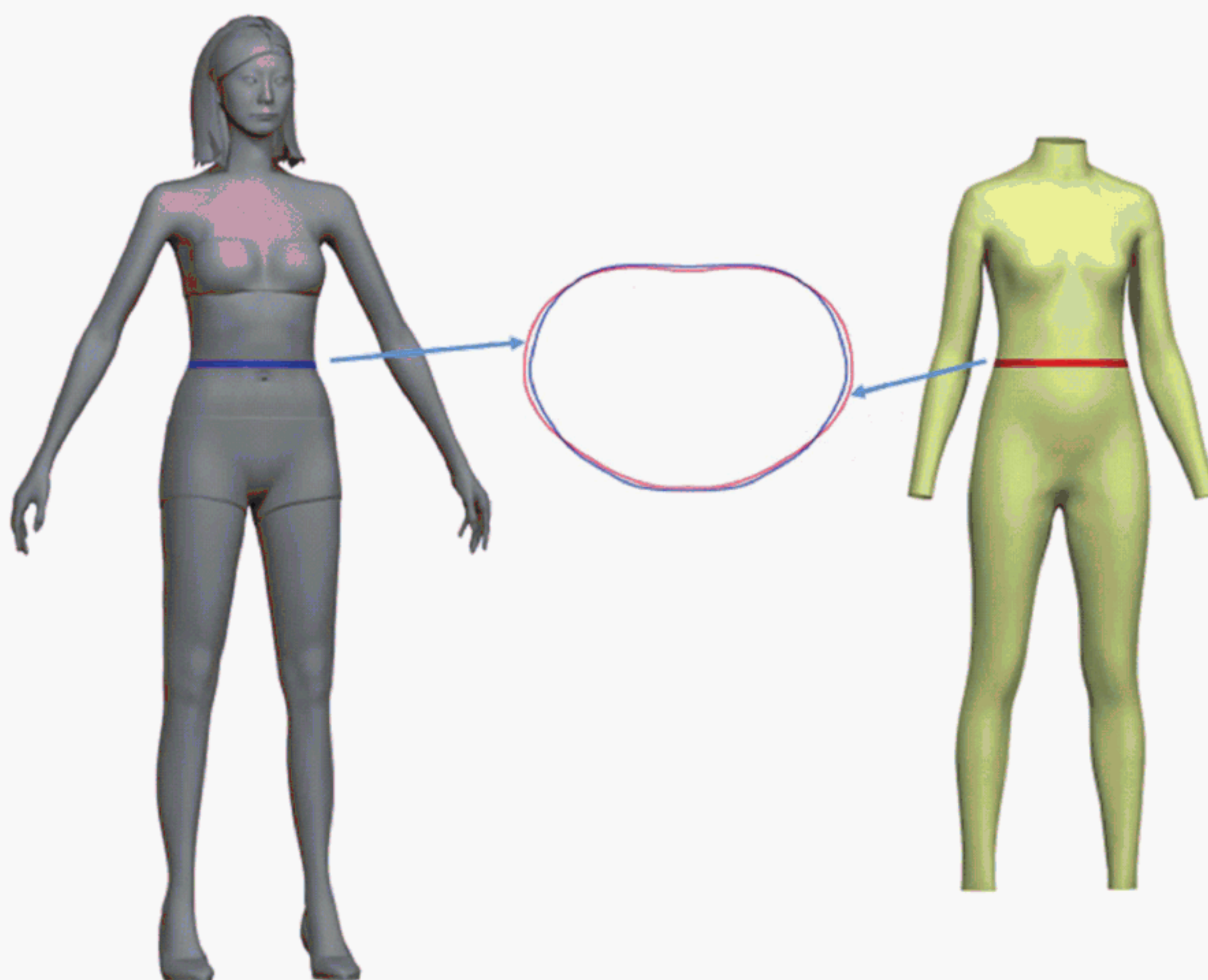


The maximum, the minimum, the mean and the standard deviation of numbers of vertices in the virtual human bodies without heads, hands or feet shall be reported. If all of the numbers in the virtual human bodies are common, their maximum, minimum, mean, standard deviation are not necessary to be reported.

## 7 Cross sections and projection views

### 7.1 General

Two dimensional shapes of the virtual human body and that of the human body are shown for visual inspection. The cross section, front, back and side views for both the human body and the virtual human body are obtained and presented with the following method ([Figure 7](#)). To acquire the cross sectional view of the human body, 3D body scanner and sliding gauge may be used. A virtual clone whose accuracy is well assessed, can be used as a reference in evaluation for a virtual twin or a virtual fit mannequin. Examples of report for the evaluation of a virtual twin or virtual fit mannequin are shown in [Tables E.1](#) to [E.3](#).



**Figure 7 — Evaluation with cross sections**  
(left: scanned human data, right: virtual twin)



**Table 3 — Body cross sections used in evaluation**

	Cross section	Level	Requirement
1	Chest cross section	Virtual axilla point (right)	required for male
2	Bust cross section	Virtual bust point (right)	required for female
3	Underbust cross section	Virtual underbust point	optional for female
4	Midriff cross section	Virtual midriff level	optional for female
5	Waist cross section	Virtual side waist point	required
6	Top hip cross section	Virtual top hip level	required
7	Hip cross section	Virtual hip point	required
8	Thigh cross section (right)	Virtual gluteal fold point(right)	required
9	Thigh cross section (left)	Virtual gluteal fold point (left)	required

## 7.2 Cross section

Each of cross sections in [Table 3](#) (six for males and eight for females) is presented as follows. The cross section of the virtual human body is superimposed on that of the human body in a way that the centres of bounding rectangles of the two cross section shapes match. The cross sections are shown with the front of the body facing downward. The two cross sections are drawn with lines in clearly distinguishable colours or colour densities. The lines should be thick enough to clearly show the cross-sectional shape. The bounding rectangles, whose edges are in the lateral or anteroposterior direction are also superimposed on the cross sections.

NOTE See the first part of [Table C.7](#).

## 7.3 Superimposed display of torso cross sections

A diagram showing the bust (chest for men), waist and hip cross sections projected in the vertical direction is created for each person for assessing the posture in the standing position, e.g. degree of chest prominence or rounding shoulder. Diagrams of the human body and the virtual human body are shown side by side, with the front facing downward. The three cross sections are drawn with lines that are thick enough to clearly show the shape and in clearly distinguishable colours or colour densities.

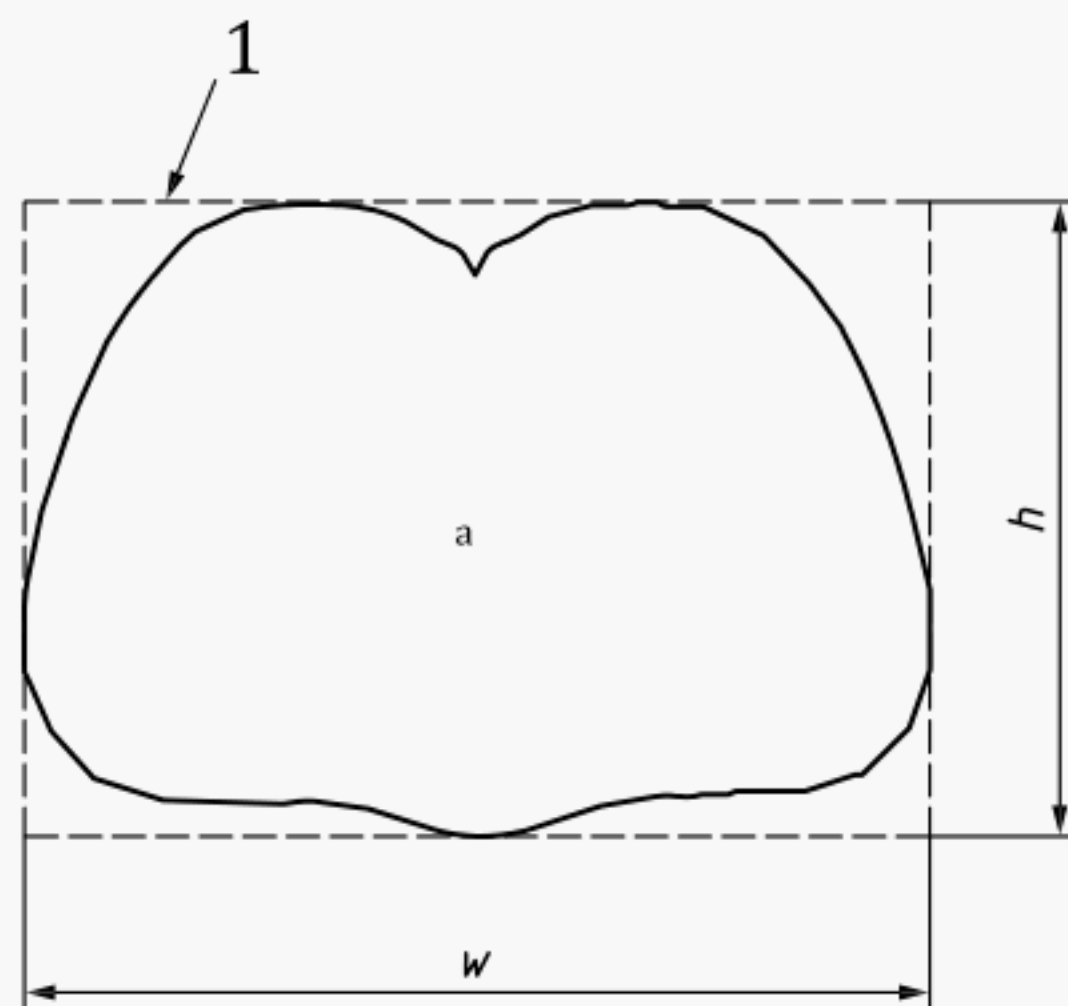
NOTE See second part of [Table C.7](#).

## 7.4 Dimensions of bounding rectangles of cross sections

The lateral and anteroposterior dimensions of the bounding rectangle are obtained for bust (chest for men), underbust (only for women), waist, and hip cross sections of both the virtual human body and the human body. The width and depth of the bounding rectangle are calculated as the lateral dimension divided by the anteroposterior dimension.

NOTE See [Table C.8](#).





#### Key

- 1 bounding rectangle
- $h$  anteroposterior dimension ( $h$  mm)
- $w$  lateral dimension ( $w$  mm)
- $a$  Width and depth =  $w \div h$ .

**Figure 8 — Dimensions of bounding rectangle of cross section**

## 7.5 Front, back and side views

The front, back and side views of the human body and the virtual human body are presented side by side. The head can be excluded from display. The views of the human body are its photographs or images from its 3D body scanned data. The positions for the bust (chest for men), under bust (only for women), waist, and hip cross-sections are shown on the front, back and side views with line segments. The superimposed silhouette image of the human body and the virtual human body are also presented on each of the front, back and side views.

NOTE See [Table C.9](#).

## 8 Report

### 8.1 General

Available functions, information on subjects used for evaluation, and results of evaluation using body dimensions, cross sectional shapes, and frontal and side views shall be reported using formats in [Annex A](#). Examples of report are also shown in [Tables B.1 to B.7](#), [Tables C.1 to C.9](#) and [Tables D.1 to D.3](#).

### 8.2 Information on the virtual human modelling system

General information on the virtual human modelling system shall be reported using the format shown in [Table A.1](#).

### 8.3 Availability of the recommended functions

Availability of the recommended functions of the virtual human modelling system specified in [Clause 4](#) shall be reported in the format shown in [Table A.2](#). The positions of the landmarks that can be exported as output data shall be reported in the format of [Table A.3](#). The list should identify clearly the landmark positions that have been actually measured or those that were estimated.



## 8.4 Information on subject population

The statistical values for the target population described in [Clause 5](#) and the height and chest girth (for male) or bust girth (for female) of the subjects used for evaluation shall be reported in the format of [Table A.4](#).

## 8.5 Measurement errors

The evaluation results on body dimension accuracy described in [Clause 6](#) shall be reported in the format of [Table A.5](#). The measurements for all subjects and for the virtual human bodies should preferably be reported in the format shown in [Table A.6](#).

## 8.6 Cross sections and projection views

The cross-sectional views described in [7.2](#) and [7.3](#) shall be reported in the format of [Table A.7](#).

Statistical analysis of cross section data is used to compare the difference between physical and virtual data, e.g. bounding rectangle analysis (see [Table A.8](#)).

The projection view described in [7.4](#) shall be reported in the format of [Table A.9](#).

## Annex A

### (normative)

## Format for report: Evaluation of a virtual human modelling system

**Table A.1 — General Information**

<b>Name of the system evaluated and its manufacturer</b>	
<b>Method to create virtual human body</b>	1. based on 3D body scan data 3D body scanner used and manufacturer: 2. based on body dimensions data Body dimensions used: 3. other (please specify: )
<b>Evaluated by</b>	
<b>Date of evaluation</b>	
<b>Output format</b>	
<b>Target body part</b>	

**Table A.2 — Recommended Functions**

Function	Availability

**Table A.3 — Exported Landmarks**

Landmark	Measured / Estimated

**Table A.4 — Information of subjects**

Male	(Nationality) Age: XX-XX years				Female	(Nationality) Age: XX-XX years		
	5 percentile	Mean	95 percentile			5 percentile	Mean	95 percentile
<b>Stature (mm)</b>					<b>Stature (mm)</b>			
<b>Chest girth (mm)</b>					<b>Bust girth (mm)</b>			

Person	Stature (mm)	Chest girth (mm)
1		
2		
3		
4		
5		

Person	Stature (mm)	Bust girth (mm)
1		
2		
3		
4		
5		



Person	Stature (mm)	Chest girth (mm)
6		
7		
8		
9		

Person	Stature (mm)	Bust girth (mm)
6		
7		
8		
9		

Table A.5 — Statics of errors in body dimensions (mm)

Male					
	Mean	Standard deviation	Minimum	Maximum	Mean Absolute error
Number of vertices without head, hands, feet					
Body dimension	Mean	Standard deviation	Minimum	Maximum	
Chest girth					
Waist girth					
Hip girth					
Thigh girth (right)					
Thigh girth (left)					
Chest height					
Waist height					
Hip height					
Thigh height (right)					
Thigh height (left)					
Arm length (right)					
Arm length (left)					
Upper arm girth (right)					
Upper arm girth (left)					
Wrist girth (right)					
Wrist girth (left)					
Inside leg height					
Back waist length					
Shoulder width					
Shoulder slope (right) (degree of angle)					
Shoulder slope (left) (degree of angle)					
Shoulder length (right)					
Shoulder length (left)					



Female					
	Mean	Standard deviation	Minimum	Maximum	Mean Absolute error
Number of vertices without head, hands, feet					
Body dimension	Error				
	Mean	Standard deviation	Minimum	Maximum	
Bust girth					
Underbust girth					
Waist girth					
Hip girth					
Thigh girth (right)					
Thigh girth (left)					
Bust height					
Underbust height					
Waist height					
Hip height					
Thigh height (right)					
Thigh height (left)					
Arm length (right)					
Arm length (left)					
Upper arm girth (right)					
Upper arm girth (left)					
Wrist girth (right)					
Wrist girth (left)					
Inside leg height					
Back waist length					
Shoulder width					
Shoulder slope (right) (degree of angle)					
Shoulder slope (left) (degree of angle)					
Shoulder length (right)					
Shoulder length (left)					



**Table A.6 — Virtual human body measurement results of specified individual (mm)**

<b>ID:</b>			
<b>Male/Female:</b>	<b>Age:</b>	<b>Stature:</b>	<b>Weight (Kg):</b>
<b>Body dimension</b>	<b>Virtual human body</b>	<b>Human body</b>	<b>Error</b>
Chest girth / Bust girth			
Underbust girth			
Waist girth			
Hip girth			
Thigh girth (right)			
Thigh girth (left)			
Chest height / Bust height			
Underbust height			
Waist height			
Hip height			
Thigh height (right)			
Thigh height (left)			
Arm length (right)			
Arm length (left)			
Upper arm girth (right)			
Upper arm girth (left)			
Wrist girth (right)			
Wrist girth (left)			
Inside leg height			
Back waist length			
Shoulder width			
Shoulder slope (right) (degree of angle)			
Shoulder slope (left) (degree of angle)			
Shoulder length (right)			
Shoulder length (left)			



Table A.7 — Cross Section

Sample No:	
Male/Female	
Virtual parametric body model	(colour of lines)
Scanned human data	(colour of lines)

Bust	Underbust
Midriff	Waist
Top hip	Hip
Thigh right	Thigh left

Bust	(colour of a line)
Waist	(colour of a line)
Hip	(colour of a line)
Virtual parametric body model	Scanned human data



Table A.8 — Dimensions of bounding rectangle of cross section

<b>ID:</b>	<b>Female:</b>					
Cross section	Virtual parametric body model			Scanned human data		
	Width (mm)	Depth (mm)	Width and depth	Width (mm)	Depth (mm)	Width and depth
Bust						
Underbust						
Midriff						
Waist						
Top hip						
Hip						

<b>ID:</b>	<b>Male:</b>					
Cross section	Virtual parametric body model			Scanned human data		
	Width (mm)	Depth (mm)	Width and depth	Width (mm)	Depth (mm)	Width and depth
Chest						
Waist						
Top hip						
Hip						

Table A.9 — Front, back and side view

<b>ID:</b>	
<b>Male/Female</b>	

	Virtual parametric body model	Scanned human data	Superimposed
<b>Front view</b>			
<b>Back view</b>			
<b>Side view</b>			

## Annex B (informative)

### Example of report: Evaluation of a virtual human modelling system based on 3D body scan data

**Table B.1 — General Information**

<b>Name of the system evaluated and its manufacturer</b>	VG2020 AB Virtual Graphics (Pty Ltd)
<b>Method to create virtual human body</b>	1. based on 3D body scan data 3D body scanner used and manufacturer: AB Virtual Graphics Body Line Scanner
<b>Evaluated by</b>	C. Greenwood
<b>Date of evaluation</b>	2018/4/2
<b>Output format</b>	Digital
<b>Target body part</b>	Entire body

**Table B.2 — Recommended Functions**

Function	Availability
Symmetrisation function	Available
Landmark export function	Available

**Table B.3 — Exported Landmarks**

Landmark	Measured / Estimated
Back neck point	Measured by marker
Bust point	Estimated



Table B.4 — Information of subjects

Male	Nationality: Japanese Age: 21-25 years				Female	Nationality: Japanese Age: 21-35 years		
	5 percentile	Mean	95 percentile			5 percentile	Mean	95 percentile
Stature (mm)	1 570	1 690	1 790		Stature (mm)	1 470	1 549	1 610
Chest girth (mm)	810	950	1		Bust girth (mm)	750	850	970

Person	Stature (mm)	Chest girth (mm)
1	1 567	829
2	1 570	831
3	1 600	847
4	1 715	907
5	1 728	914
6	1 681	889
7	1 766	934
8	1 795	950
9	1 784	944

Person	Stature (mm)	Bust girth (mm)
1	1 501	774
2	1 476	761
3	1 470	758
4	1 567	808
5	1 547	797
6	1 545	796
7	1 610	830
8	1 613	831
9	1 611,5	831

Table B.5 — Statics of errors in body dimensions (mm)

Male					
Body dimension	Error				Mean absolute error
	Mean	Standard deviation	Minimum	Maximum	
Chest girth	-220	309	-560	260	304
Waist girth	357		140	730	357
Hip girth	371	108	220	520	371
Thigh girth (right)	59	86	-40	240	74
Thigh girth (left)	-	-	-	-	-
Chest height	-329	162	-575	-142	329
Waist height	-99	234	-660	110	130
Hip height	94	112	-78	214	118
Thigh height (right)	78	88	-80	228	168
Thigh height (left)	79	94	-84	223	157
Arm length (right)	59	100	-40		115
Arm length (left)	58	124	-45	163	102
Upper arm girth (right)	2,8	3,5	-2	7,6	5,8
Upper arm girth (left)	28	25	-24	81	55
Wrist girth (right)	16	18	-12	40	25
Wrist girth (left)	16	28	-10	35	28
Inside leg height	-12	88	-154	90	65
Shoulder width	-180	119	-430	-40	
Back neck point to waist	-334	161	-560	-70	334
Shoulder slope (right) (angle of degree)	-6,3	5,5	-18,9	4,7	6,4
Shoulder slope (left) (angle of degree)	-7,0	6,6	-17,2	4,0	8,0
Shoulder length (right)	11	55	-21	44	33
Shoulder length (left)	10	45	-19	38	28

Female					
Body dimension	Error				Mean Absolute error
	Mean	Standard deviation	Minimum	Maximum	
Bust girth		88	24	320	
Underbust girth	204	206	12	528	204
Waist girth	250	171	9	590	250
Hip girth		138	-32	365	152
Thigh girth (right)	74	51	-18	124	78
Thigh girth (left)	-	-	-	-	-
Bust height	-1	81	-154	140	54
Underbust height	-22	23	-65	7	23
Waist height	5	92	-220	86	59
Hip height	56	95	-25	298	61
Thigh height (right)	55	62	-56	160	118



Female					
Body dimension	Error				Mean
	Mean	Standard deviation	Minimum	Maximum	Absolute error
Thigh height (left)	55	66	-59	156	110
Arm length (right)	41	70	-28	132	81
Arm length (left)	41	87	-32	114	71
Upper arm girth (right)	20	25	-14	53	41
Upper arm girth (left)	20	18	-17	57	39
Wrist girth (right)	11	13	-8	28	18
Wrist girth (left)	11	20	-7	25	20
Inside leg height	109	32	64	171	109
Shoulder width	-55	103	-195	111	100
Back neck point to waist	-56	234	-430	320	12
Shoulder slope (right) (degree of angle)	-6,4	4,8	-13	1,6	6,8
Shoulder slope (left) (degree of angle)	-5,0	6,2	-12,1	2,9	6,5
Shoulder length (right)	8	39	-15	31	23
Shoulder length (left)	7	32	-13	27	20

**Table B.6 — Virtual human body measurement results of specified individual (mm)**

<b>ID:</b> 20011185335081			
<b>Male/Female:</b> Female	<b>Age:</b> 35	<b>Stature:</b> 1 501,0	<b>Weight (Kg):</b> 48,3
<b>Body dimension</b>	<b>Virtual human body</b>	<b>Human</b>	<b>Error</b>
Bust girth	829,8	826,0	3,8
Underbust girth	655,2	645,0	1,2
Waist girth	649,8	627,0	22,8
Hip girth	837,0	818,0	19,0
Thigh girth (right)	460,0	452,0	8,0
Thigh girth (left)	460,0	452,0	8,0
Bust height	1 052,0	1 051,0	1,0
Underbust height	997,9	1 001,0	-3,1
Waist height	909,5	910,5	-1,0
Hip height	748,0	748,0	0,0
Thigh height (right)	723,3	725,9	-2,6
Thigh height (left)	724,2	715,2	9,0
Arm length (right)	572,2	553,0	19,2
Arm length (left)	571,9	590,9	-19,0
Upper arm girth (right)	252,4	247,1	5,3
Upper arm girth (left)	253,1	243,3	9,8
Wrist girth (right)	150,0	156,1	-6,1
Wrist girth (left)	153,2	157,1	-3,9
Inside leg height	672,4	666,0	6,4
Back waist length	344,0	387,0	-43,0
Back shoulder width	387,0	396,0	-9,0
Shoulder slope (right) (degree of angle)	23,2	30,0	-6,8
Shoulder slope (left) (degree of angle)	24,1	36,0	-11,9
Shoulder length (right)	154,8	153,2	2,6
Shoulder length (left)	152,8	153,2	-0,4



**Table B.7 — Virtual human body measurement results of specified individual (mm)**

<b>ID:</b> 1912010098082			
<b>Male/Female:</b> Female	<b>Age:</b> 48	<b>Stature:</b> 1 714	<b>Weight (Kg):</b> 63,9

<b>Body dimension</b>	<b>Virtual human body</b>	<b>Human</b>	<b>Error</b>
Bust girth	966	950	+16
Underbust girth	789	790	-1
Waist girth	742	770	-18
Hip girth	989	990	-1
Thigh girth (right)	564	577	-13
Thigh girth (left)	560	572	-12
Bust height	1	1 212	-9
Underbust height	1 148	1 147	+1
Waist height	1 085	1 045	+40
Hip height	858	862	-4
Thigh height (right)	723	750	-27
Thigh height (left)	723	750	-27
Arm length(right)	588	551	+37
Arm length(left)	557	549	+8
Upper arm girth(right)	313	280	+33
Upper arm girth(left)	265	272	-7
Wrist girth(right)	176	153	+23
Wrist girth(left)			0
Inside leg height	753	770	-17
Back waist length	410	410	0
Shoulder width	374	400	-26
Shoulder slope (right) (degree of angle)	18,2	-	-
Shoulder slope (left) (degree of angle)	19,1	-	-
Shoulder length (right)	140	160	-20
Shoulder length (left)	144	157	-13

NOTE The list of measurements for the virtual human body were taken from a scan using automatically located landmarks and automatically extraction measurements and the list of measurement for the Human Body were taken using manual landmarking and manual measurement extraction methods.

## Annex C

### (informative)

## Example of report: Evaluation of a virtual human modelling system based on body dimension data

**Table C.1 — General Information**

<b>Name of the system evaluated and its manufacturer</b>	VGT2010 CD Advanced Industrial Science and Technology
<b>Method to create virtual human body</b>	2. based on body dimension data Body dimensions used: Chart 5 051/2017
<b>Evaluated by</b>	A.B. Greenwood
<b>Date of evaluation</b>	2018/4/2
<b>Output format</b>	Digital
<b>Target body part</b>	Entire body

**Table C.2 — Recommended Functions**

<b>Function</b>	<b>Availability</b>
Symmetrisation function	Available
Landmark export function	Available

**Table C.3 — Exported Landmarks**

<b>Landmark</b>	<b>Measured / Estimated</b>
Back neck point	Measured
Bust point	Estimated



Table C.4 — Information of subjects

Male	Nationality: Japanese Age: 21-35 years				Female	Nationality: Japanese Age: 21-35 years		
	5 percentile	Mean	95 percentile			5 percentile	Mean	95 percentile
Stature (mm)	1 570	1 690	1 790		Stature (mm)	1 470	1 549	1 610
Chest girth (mm)	831	894	948		Bust girth (mm)	758	799	830

Person	Male/ Female	Stature	Chest girth
1	M	1 567	829
2	M	1 570	831
3	M	1 600	847
4	M	1 715	907
5	M	1 728	914
6	M	1 681	889
7	M	1 766	934
8	M	1 795	950
9	M	1 784	944

Person	Male/ Female	Stature	Bust girth
1	F	1 501	774
2	F	1 476	761
3	F	1 470	758
4	F	1 567	808
5	F	1 547	797
6	F	1 545	796
7	F	1 610	830
8	F	1 613	831
9	F	1 611,5	831

Table C.5 — Statics of errors in body dimensions (mm)

Male					
	Mean	Standard deviation	Minimum	Maximum	Mean Absolute error
No. of vertices without head, hands, feet					
Body dimension	Error				
	Mean	Standard deviation	Minimum	Maximum	
Chest girth	-220	309	-560	260	304
Waist girth	357		140	730	357
Hip girth	371	108	220	520	371
Thigh girth (right)	59	86	-40	240	74
Thigh girth (left)	-	-	-	-	-
Chest height	-329	162	-575	-142	329
Waist height	-99	234	-660	110	130
Hip height	94	112	-78	214	118
Thigh height (right)	78	88	-80	228	168
Thigh height (left)	79	94	-84	223	157
Arm length (right)	59	100	-40		115
Arm length (left)	58	124	-45	163	102
Upper arm girth (right)	28	35	-20	76	58
Upper arm girth (left)	28	25	-24	81	55
Wrist girth (right)	16	18	-12	40	25
Wrist girth (left)	16	28	-10	35	28
Inside leg height	-12	88	-154	90	65
Shoulder width	-180	119	-430	-40	
Back neck point to waist	-334	161	-560	-70	334
Shoulder slope (right) (degree of angle)	-6,3	5,5	-18,9	4,7	6,4
Shoulder slope (left) (degree of angle)	-7,0	6,6	-17,2	4,0	8,0
Shoulder length (right)	11	55	-21	44	33
Shoulder length (left)	10	45	-19	38	28

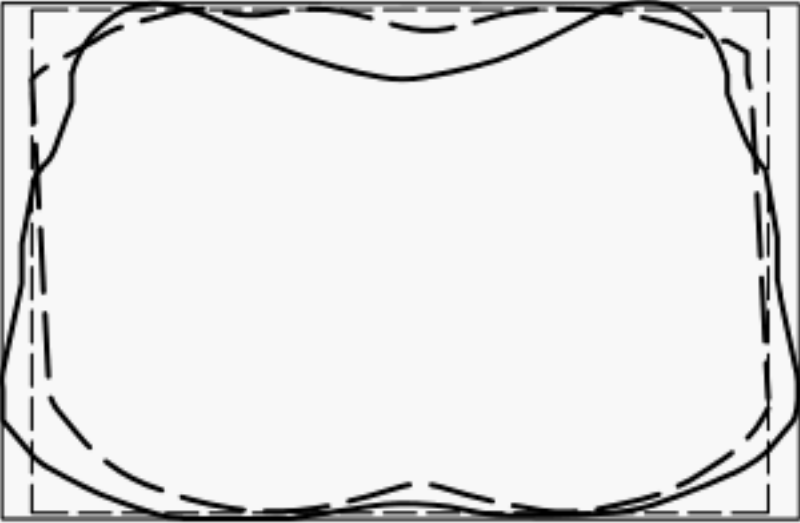
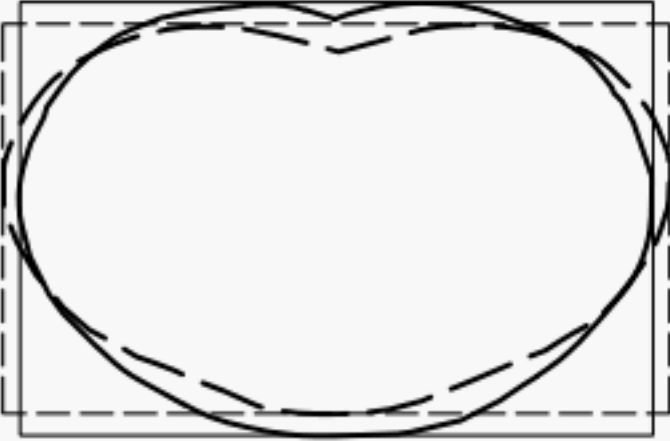
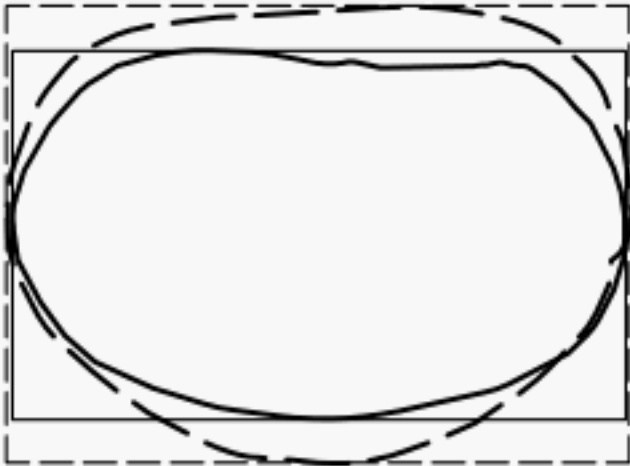

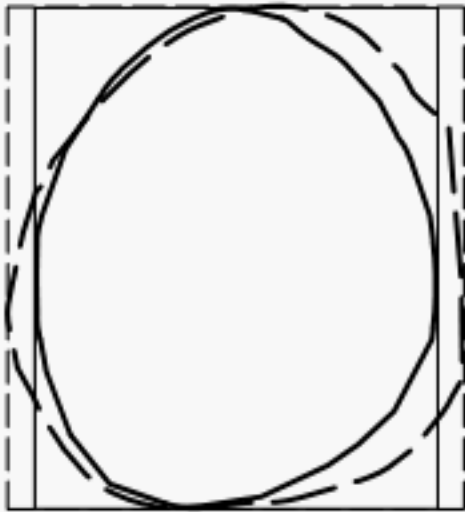
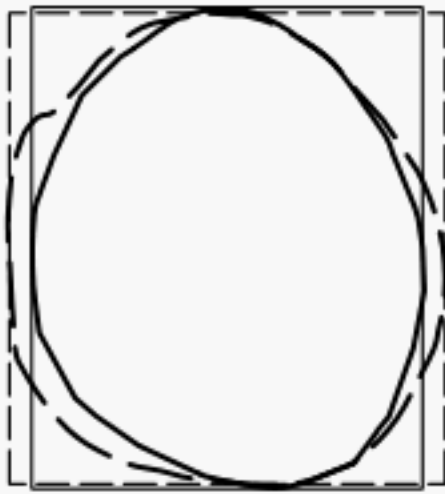


**Table C.6 — Virtual human body measurement results of specified individual (mm)**

<b>ID:</b> 1912010098082				
<b>Male/Female:</b> Male	<b>Age:</b> 35	<b>Stature:</b> 173,15		<b>Weight (Kg):</b> 68,3
Body dimension	Used for generation	Virtual human body	Human	Error
Bust girth		962,5	914,8	47,7
Waist girth		784,6	865,3	-80,7
Hip girth		905,2	969,3	-64,1
Thigh girth (right)		561,2	601,8	-40,6
Thigh girth (left)		566,8	597,2	-30,4
Bust height	✓	1 268,3	1 268,3	0
Waist height		986,3	949,2	37,1
Hip height		817,6	841,2	-23,6
Thigh height (right)	✓	737,9	737,9	0
Thigh height (left)	✓	737,9	737,9	0
Arm length (right)		429,4	415,8	13,6
Arm length (left)		429,4	422,6	6,8
Upper arm girth (right)		331,9	305,2	26,7
Upper arm girth (left)		329,3	303,5	25,8
Wrist girth (right)		123,8	178,2	-54,4
Wrist girth (left)		121,6	188,0	-66,4
Inside leg height		732,4	755,6	-23,2
Back shoulder width		365,0	392,0	-27
Back waist length		501,0	498,0	3
Shoulder slope (right) (degree of angle)		12°	25,1°	-13,1°
Shoulder slope (left) (degree of angle)		13,5°	24,0°	-10,5°
Shoulder length (right)		119	135	-16
Shoulder length (left)		107	133	-26

Table C.7 — Cross section

ID:	M01
Male/Female	Male
Virtual human body	Blue
Scanned human data	Red

Chest	Waist
	
Top hip	Hip
	
Thigh right	Thigh left
	



Chest	Red
Waist	Green
HIP	Blue
Virtual human body	Scanned human data
	



Table C.8 — Dimensions of bounding rectangle of cross section

ID: 711201	Male/Female: Male					
Cross section	Virtual human body			Scanned human data		
	lateral (mm)	Antero-posterior (mm)	Width and depth	lateral (mm)	Antero-posterior (mm)	Width and depth
Chest	355	231	1,54	328	224	1,46
Waist	297	174	1,71	281	195	1,44
Top hip	310	186	1,67	315	231	1,36
Hip	328	229	1,43	350	263	1,33
Thigh right	160	198	0,81	182	199	0,91
Thigh left	163	200	0,82	181	196	0,92

Table C.9 — Front, back and side view

Sample No:	M01	Virtual human body	Blue
Male/ Female	Male	Scanned human data	Red

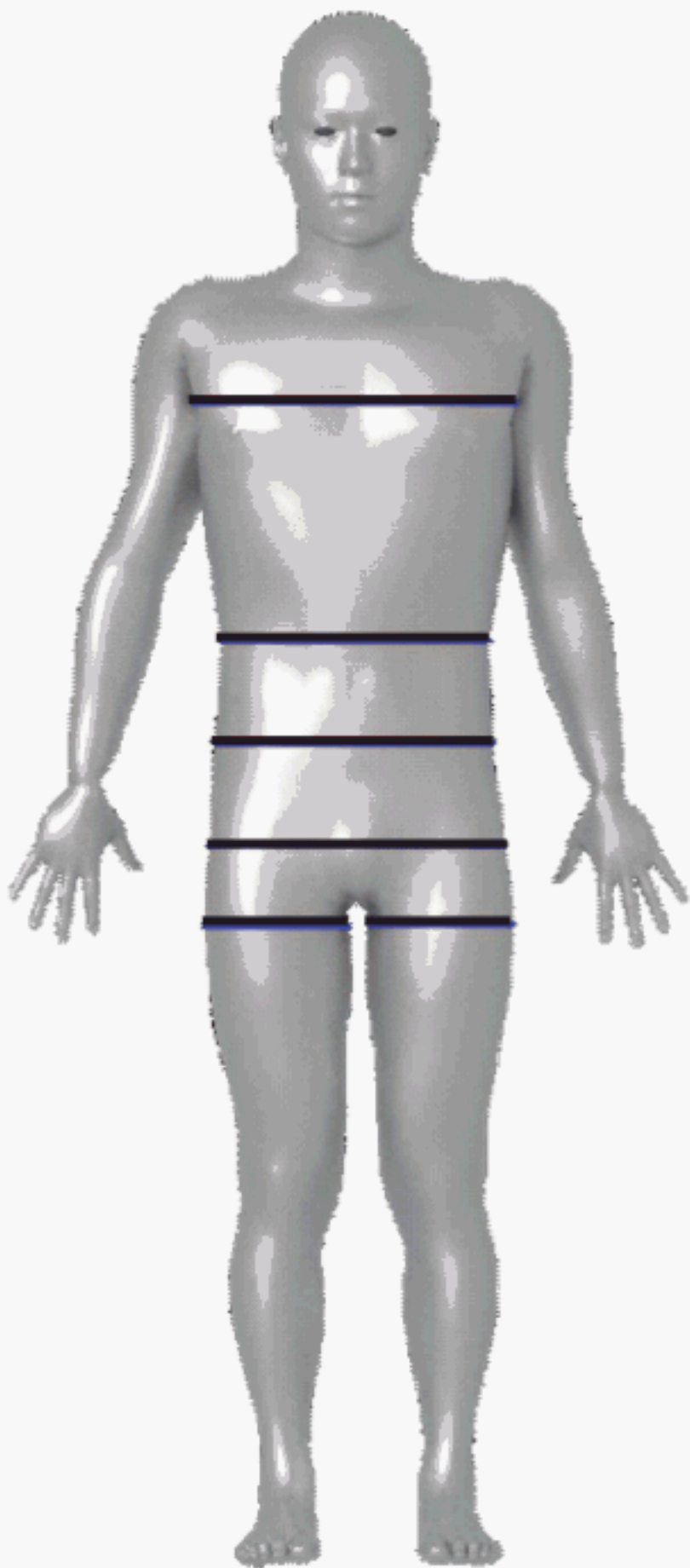
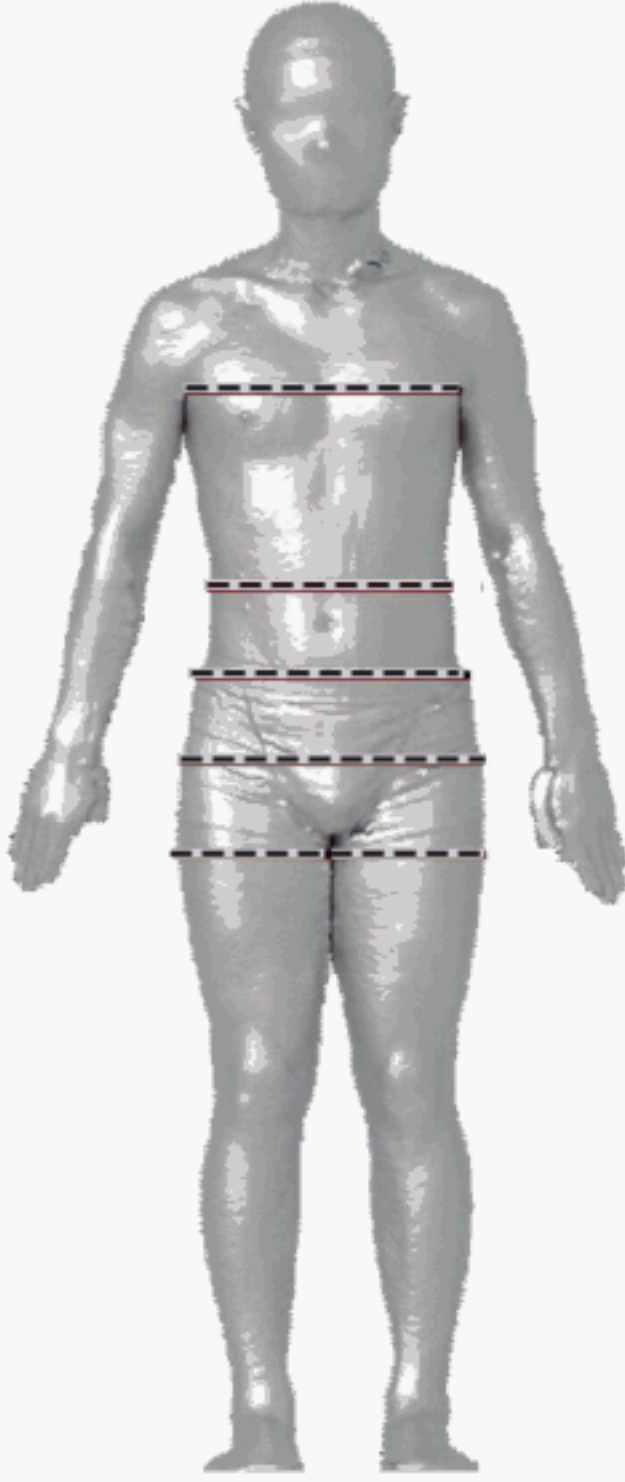
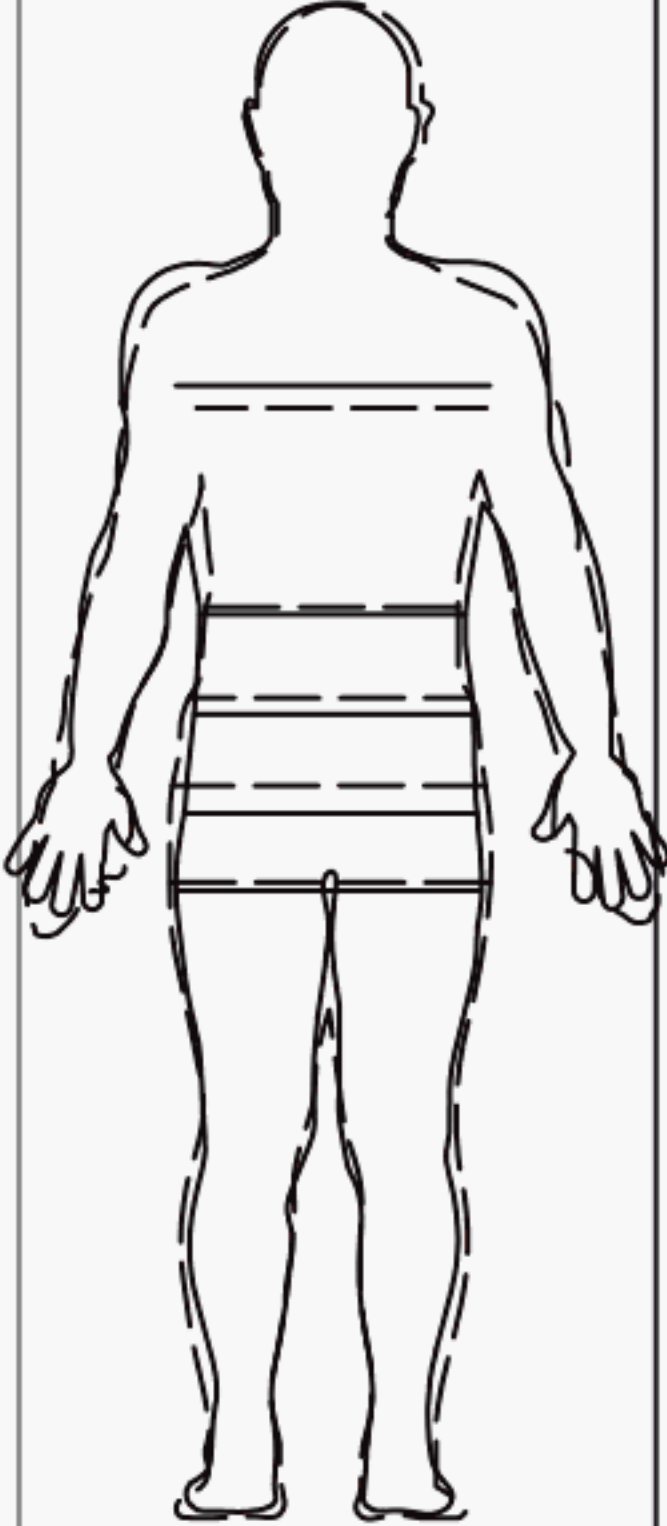
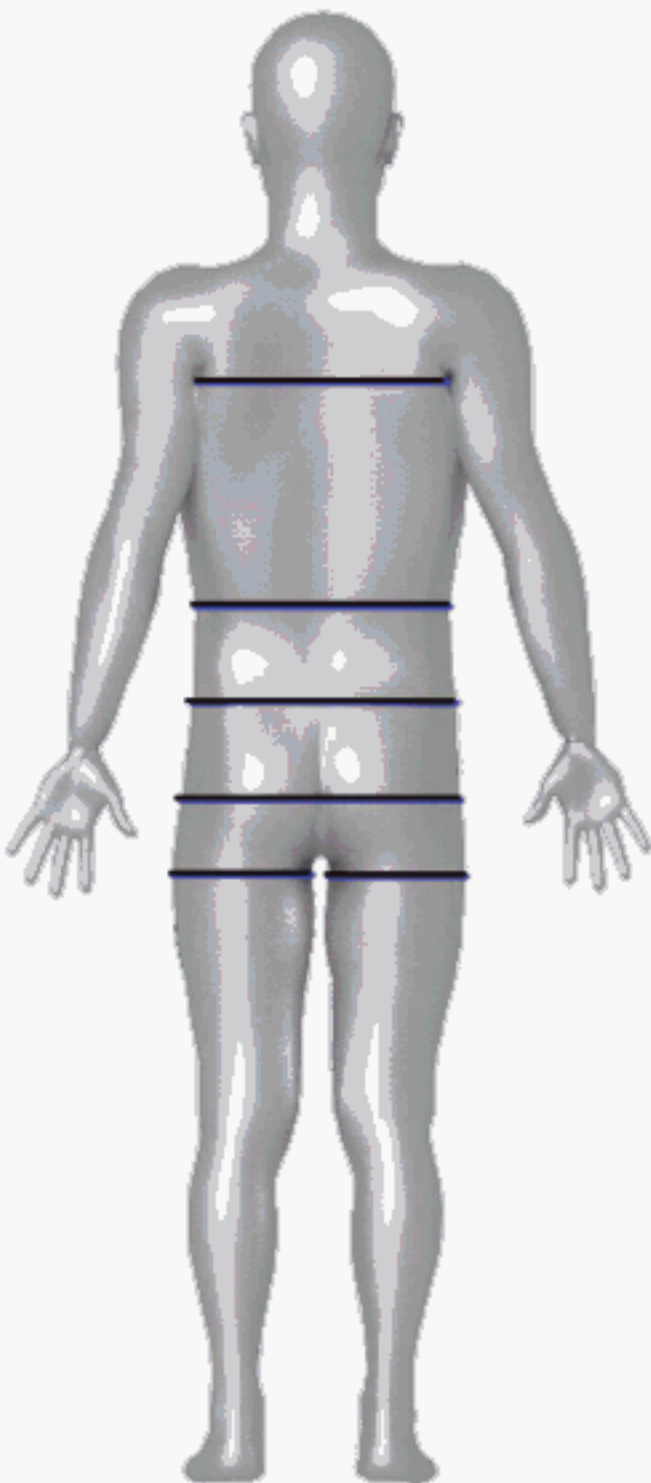
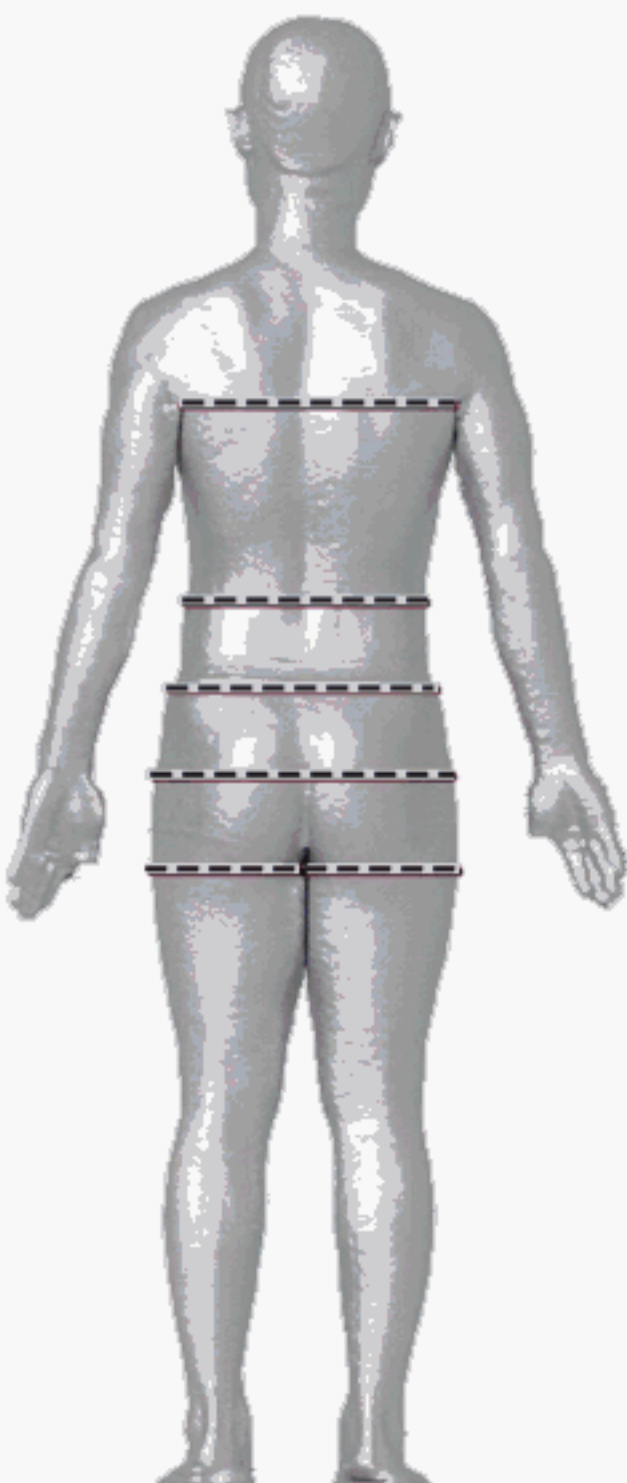
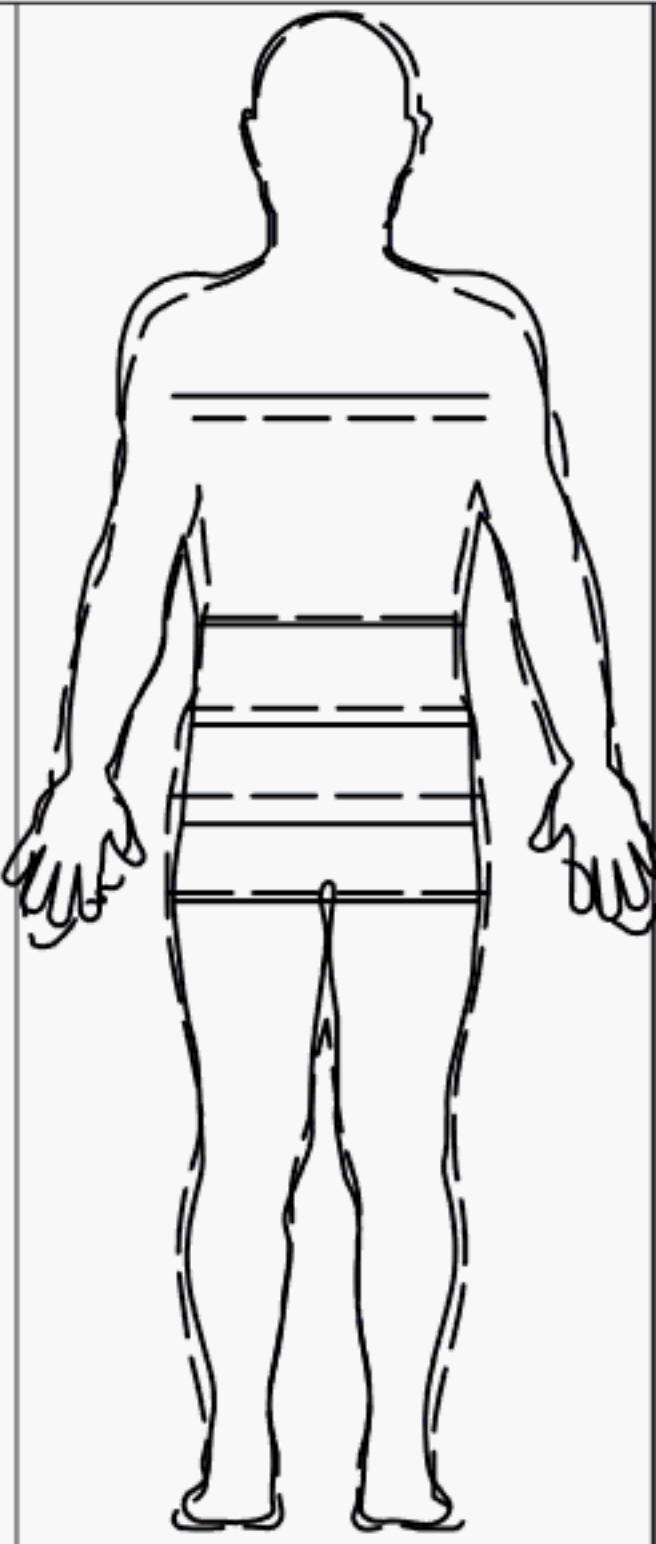



	Virtual human body	Scanned human data	Superimposed
Front view			

Table C.9 (continued)

Back view			
Side view			



## Annex D

### (informative)

### Example of report: Evaluation of a virtual human modelling system for virtual fit mannequin models

**Table D.1 — Virtual fit mannequin measurements results (mm)**

<b>ID: 791118</b>			
<b>Male/Female:</b> Female	<b>Age:</b> 48	<b>Stature:</b> 1 714	<b>Weight (Kg):</b> 63,9

<b>Body dimension</b>	<b>Virtual fit mannequin (from scan data)</b>	<b>Virtual Human body</b>	<b>Error</b>
Chest girth / Bust girth	941	966	-25
Underbust girth	791	789	+2
Waist girth	742	742	0
Hip girth	983	989	-6
Thigh girth (right)	590	564	+26
Thigh girth (left)	588	560	+28
Chest height / Bust height	1 176	1	+27
Underbust height	1 112	1 148	-36
Waist height	1 038	1 085	-47
Hip height	833	858	-25
Thigh height (right)	733	723	+10
Thigh height (left)	733	723	+10
Arm length (right)	570	588	-12
Arm length (left)	569	557	+12
Upper arm girth (right)	286	313	-27
Upper arm girth (left)	284	265	+19
Wrist girth (right)	161	176	-15
Wrist girth (left)	157		+7
Inside leg height	758	753	+5
Back neck point to waist	390	410	-20
Back shoulder width	396	374	+22
Shoulder slope (right) (degree of angle)	28°	29,1°	-1,1°
Shoulder slope (left) (degree of angle)	26°	36,0°	-10°
Shoulder length (right)	113	140	-27
Shoulder length (left)	112	144	-32

NOTE The list of measurements under each column have been taken from the scans using a mix of methods; that is, for the Virtual Fit Mannequin the landmarks were manually placed and the measurements, manually extracted and for the Human Body the landmarks automatically located and the measurements automatically extracted.

Table D.2 — Front view and side view

Sample No:	Mannequin large
Male/ Female	Female

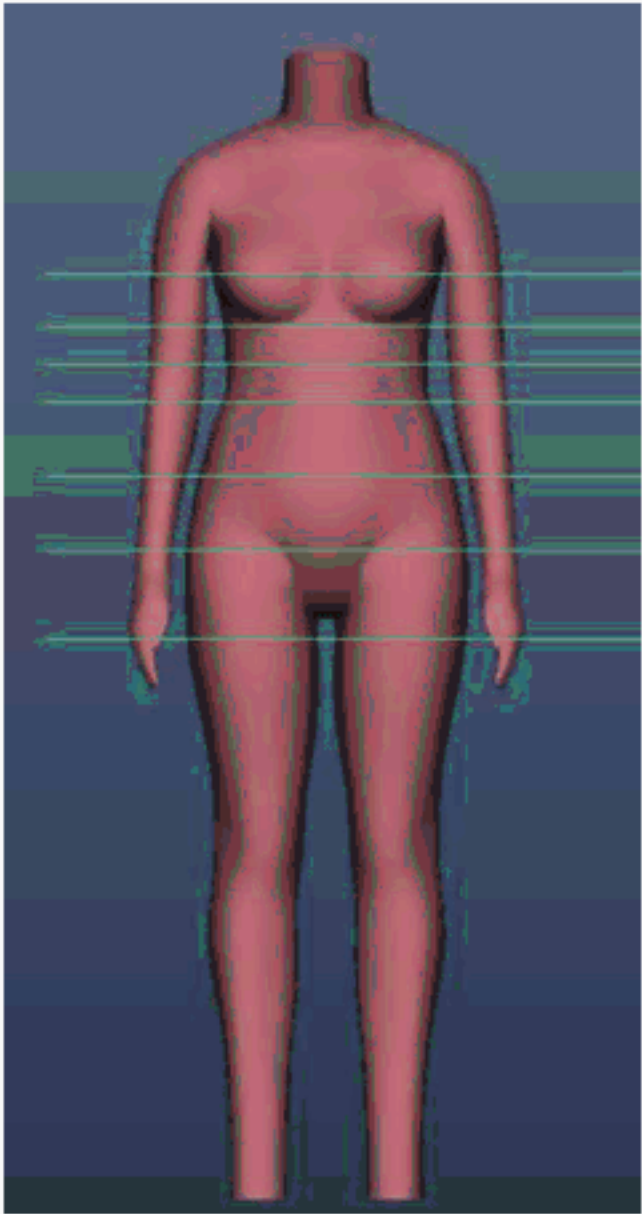
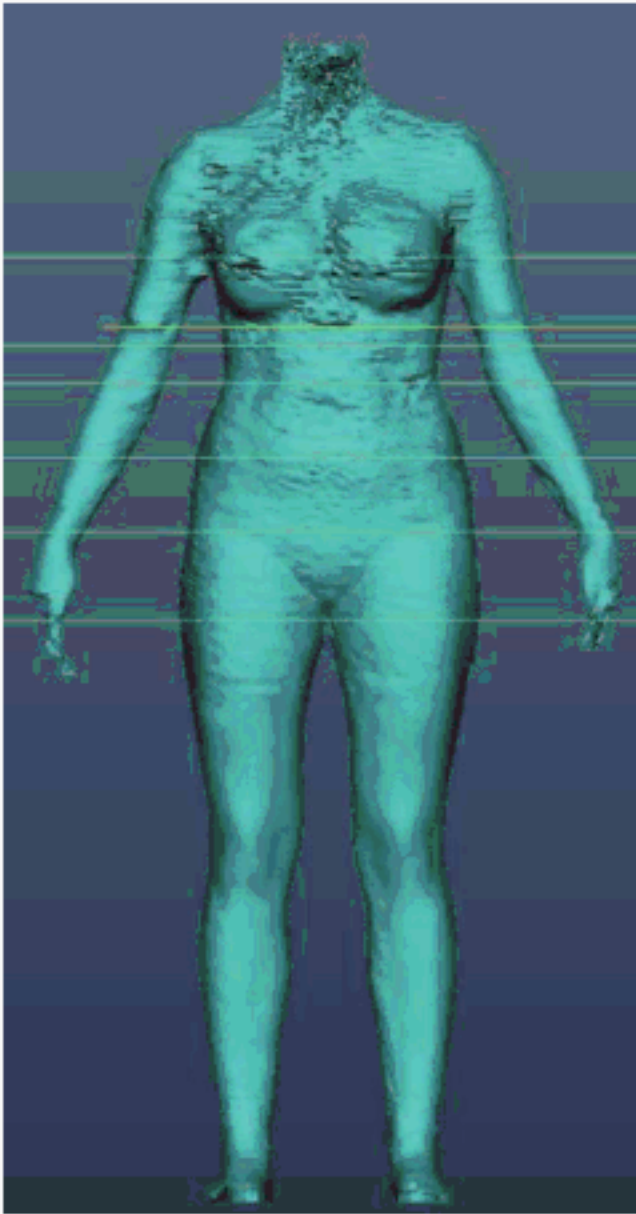

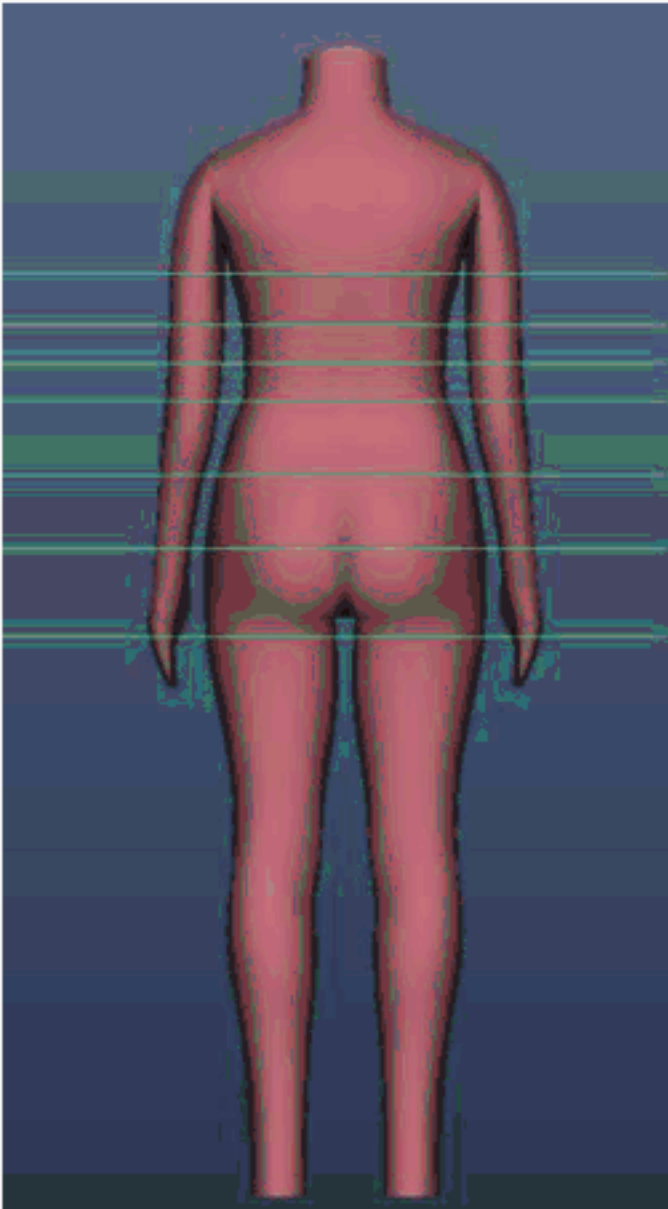
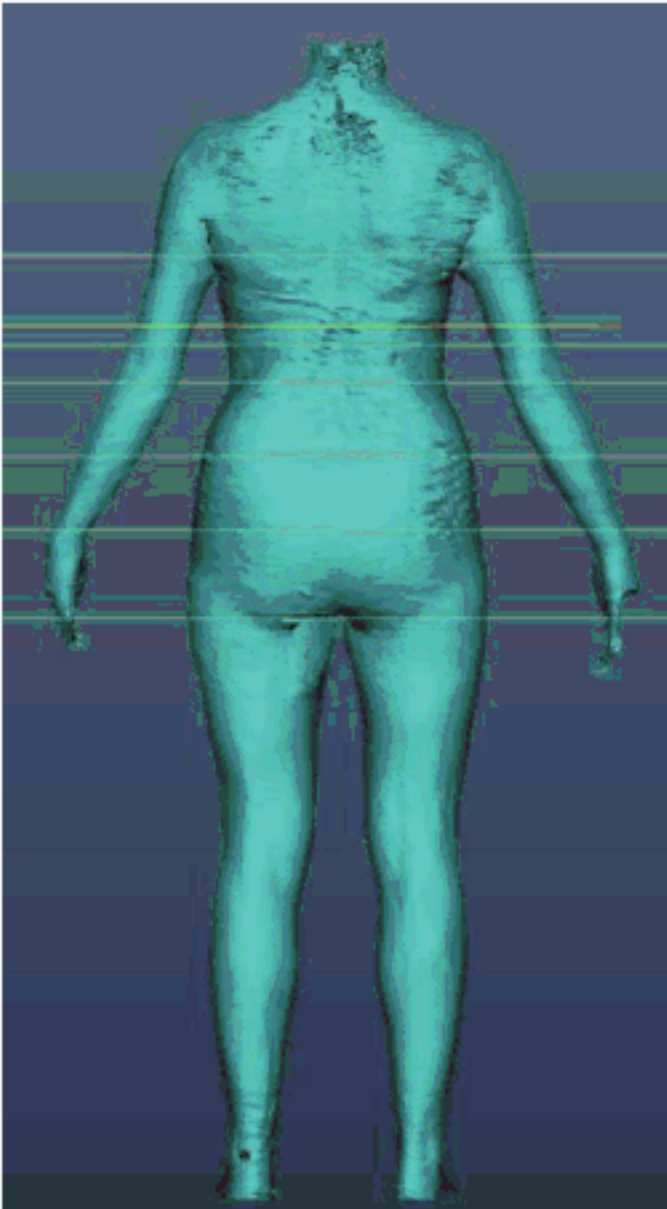
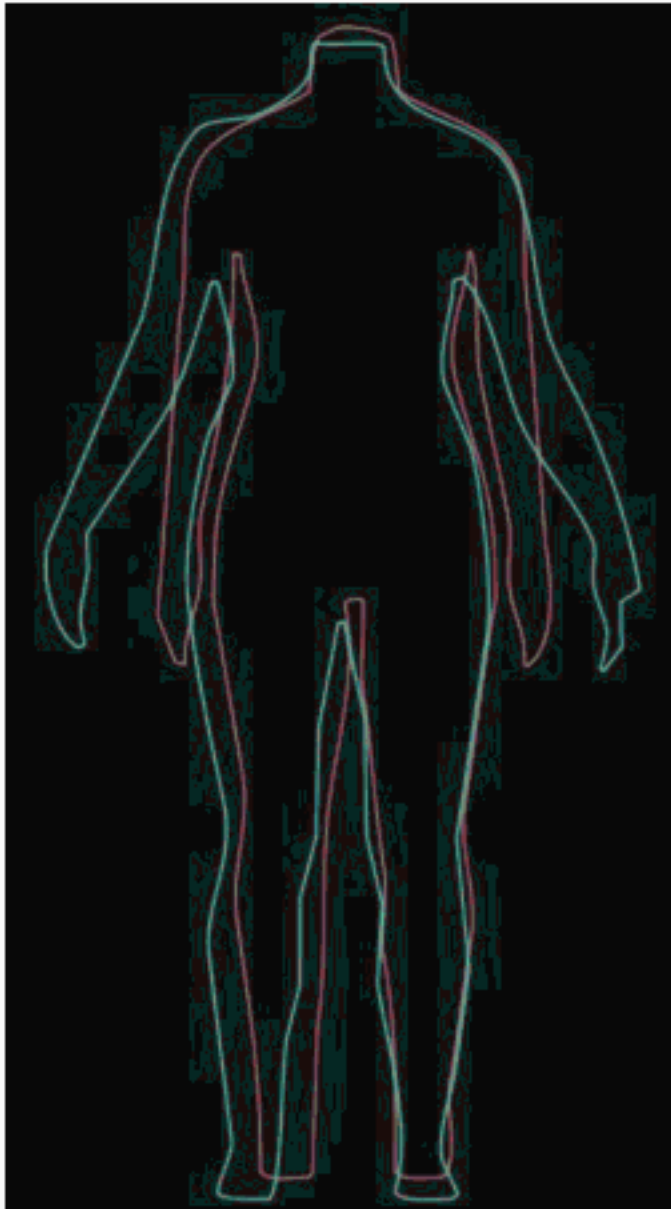
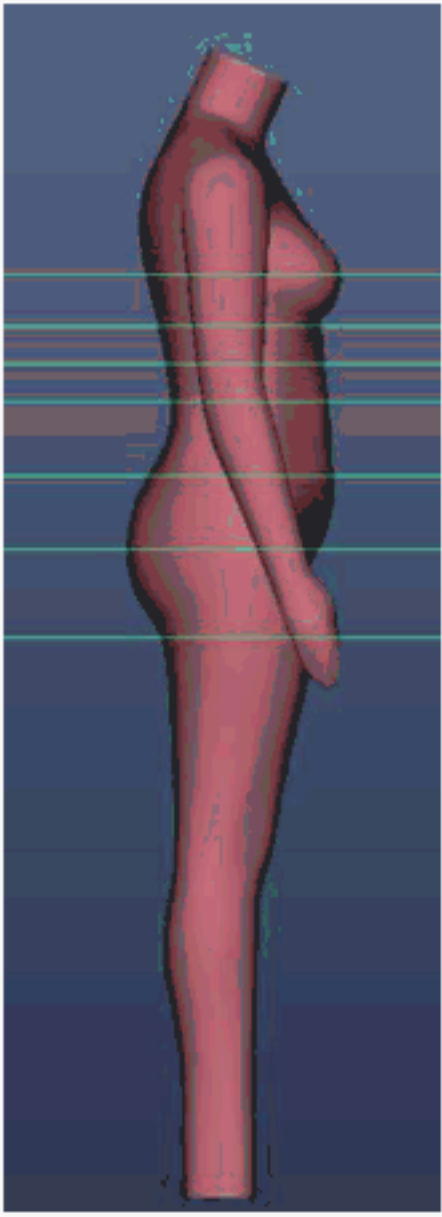
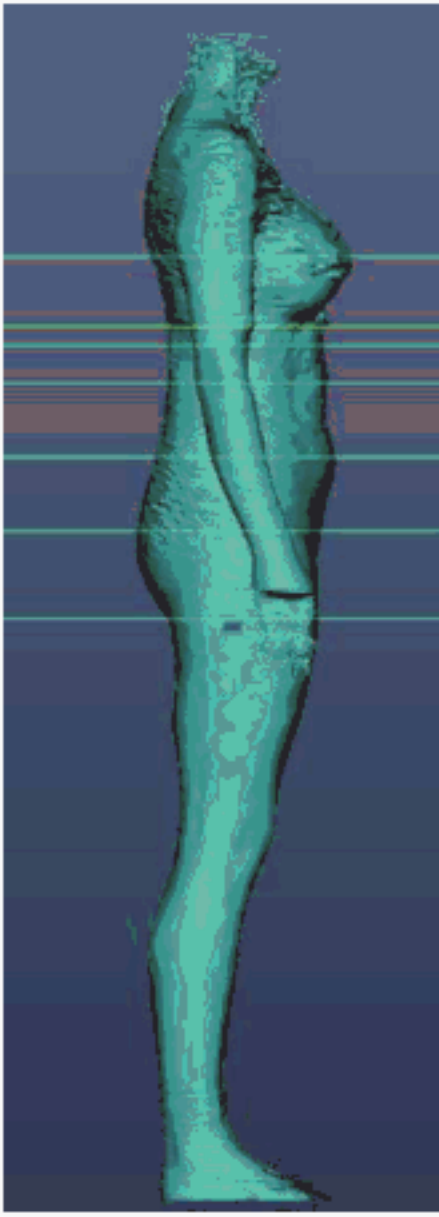
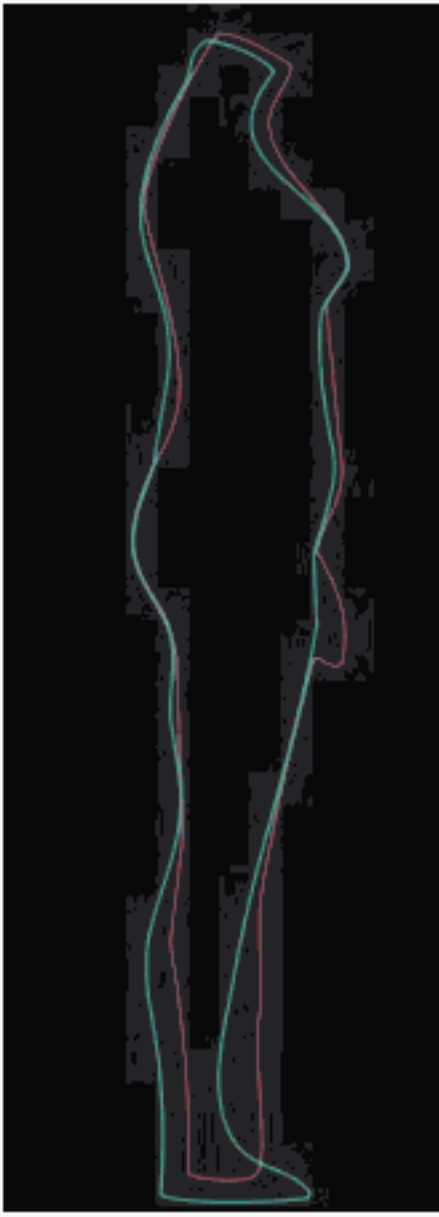
	Virtual fit mannequin model	Scanned human data	Superimposed
Front view			
Back view			




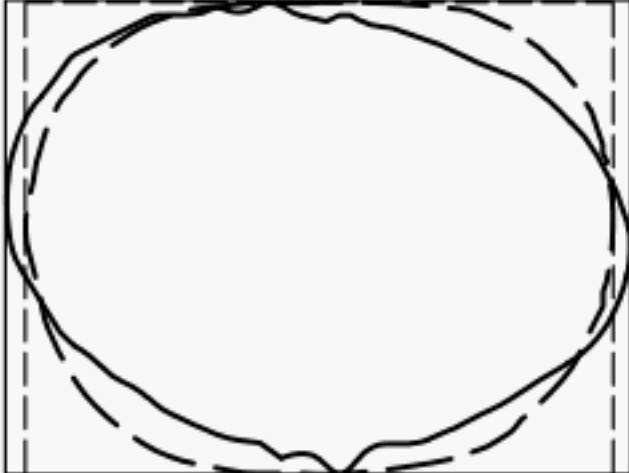

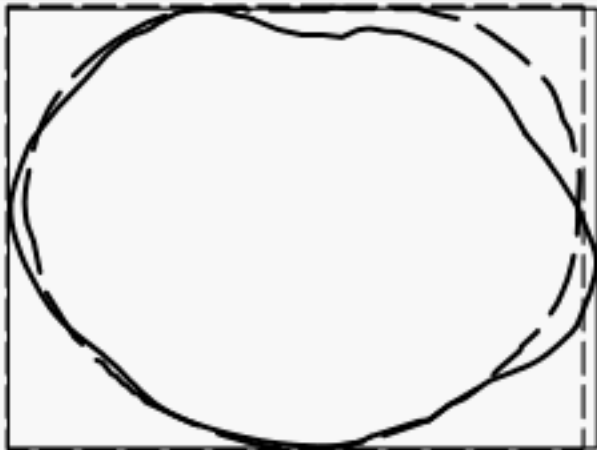
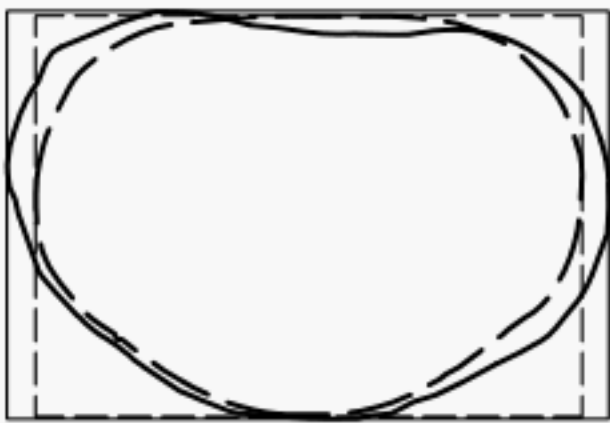

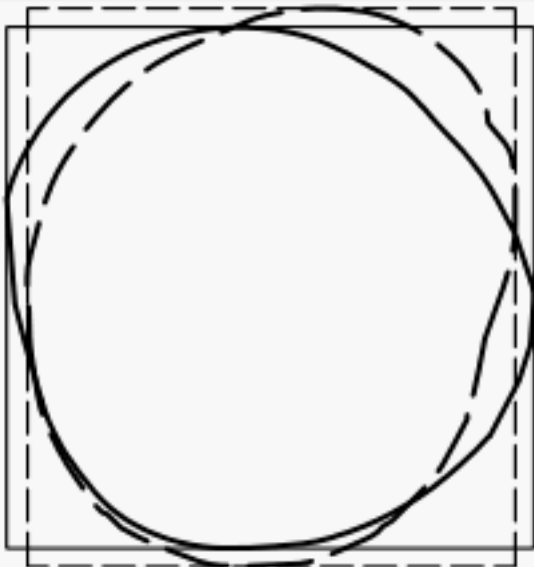
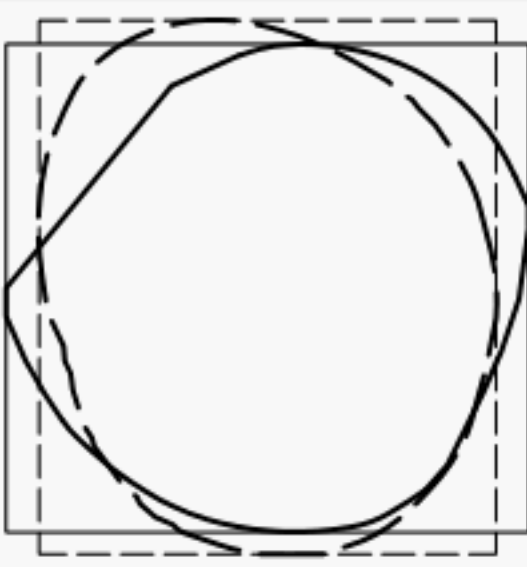
Table D.2 (continued)

<b>Side view</b>			
------------------	--	--	--

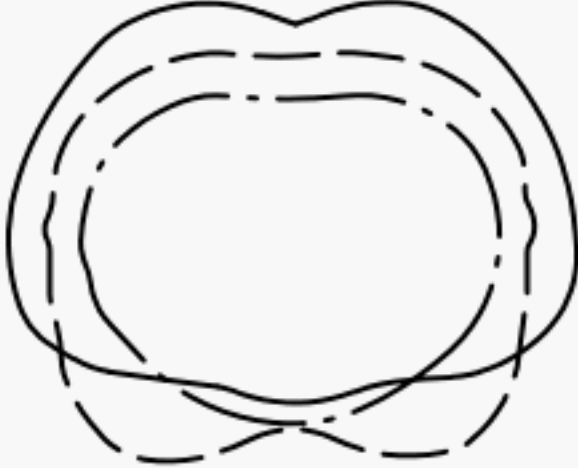
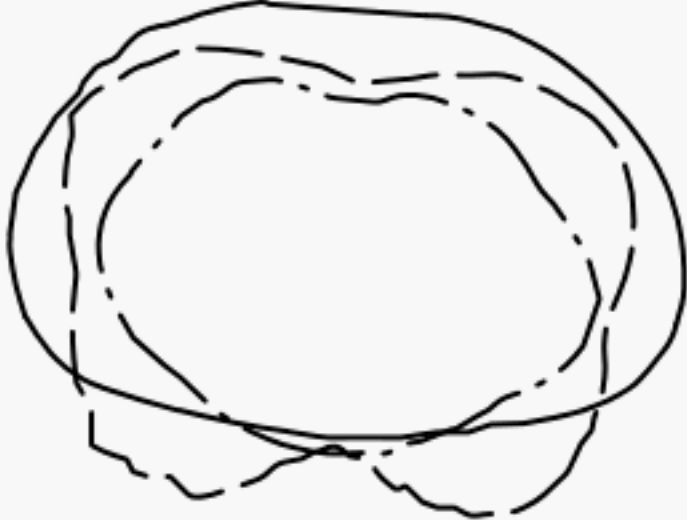
— ISO 20947-1:2021(E)

Table D.3 — Cross Section

Sample No:	Mannequin large
Male/Female	Female
Virtual fit mannequin	Red
Scanned human data	Blue

Bust	Underbust
	
Midriff	Waist
	
Top hip	Hip
	
Thigh right	Thigh left
	



Bust	Red
Waist	Green
HIP	Blue
Virtual fit mannequin	Scanned human data
	

## Annex E

### (informative)

## Format for report: Evaluation of a virtual fit mannequin

**Table E.1 — General Information**

<b>Name of the system evaluated and its manufacturer</b>	GT9000 GT Graphics and Technology (Pty. Ltd)
<b>Method to create virtual human body</b>	1. based on 3D body scan data 3D body scanner used and manufacturer: A.B. Body Line Scanner
<b>Evaluated by</b>	C.D. Applewood
<b>Date of evaluation</b>	2018/8/14

<b>Output format</b>	Digital
<b>Target body part</b>	Entire body without head, hands, feet.

**Table E.2 — Virtual fit mannequin measurement results (mm)**

<b>ID: GT20201029</b>				
<b>Male/Female: Female</b>				

<b>Body dimension</b>	<b>Virtual fit mannequin model</b>	<b>Fit mannequin</b>	<b>Error</b>
Chest girth / Bust girth	941	940	1
Underbust girth	787	780	7
Waist girth	742	740	2
Hip girth	983	985	-2
Thigh girth (right)	590	595	5
Thigh girth (left)	588	595	7
Chest height / Bust height	1 176	1	-4
Underbust height	1 110	1 110	0
Waist height	1 038	1 038	0
Hip height	833	830	3
Thigh height (right)	733	740	-7
Thigh height (left)	733	740	-7
Arm length (right)	570	580	-10
Arm length (left)	569	580	-11
Upper arm girth (right)	286	295	-9
Upper arm girth (left)	284	290	-6
Wrist girth (right)	161	160	1
Wrist girth (left)	157	160	-3
Inside leg height	758	740	18
Back waist length	380	385	-5



**Table E.2** (*continued*)

Shoulder width (tape measured)	396	380	16
Shoulder slope (right) (degree of angle)	28°	25°	3°
Shoulder slope (left) (degree of angle)	26°	25°	1°
Shoulder length (right)	113		-7
Shoulder length (left)	112		-8

Table E.3 — Front, back and side view

ID:		Virtual fit mannequin
Male/Female		Female


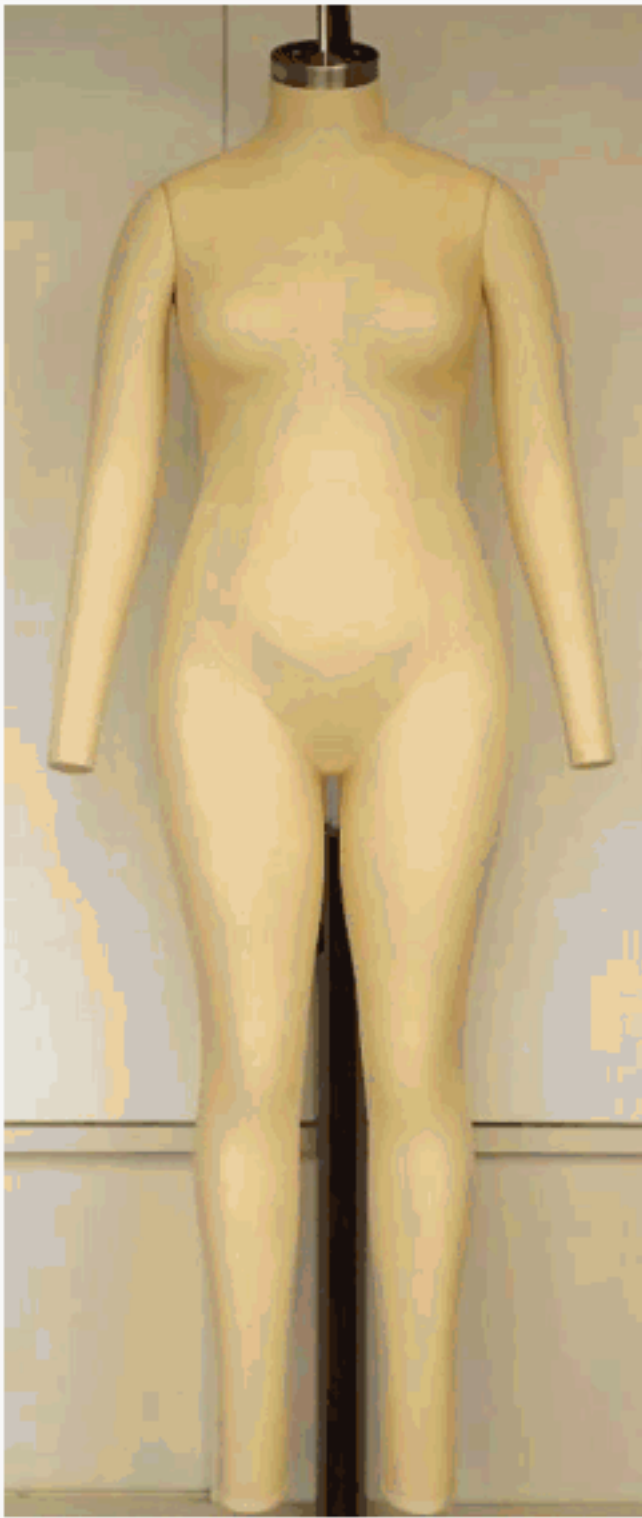

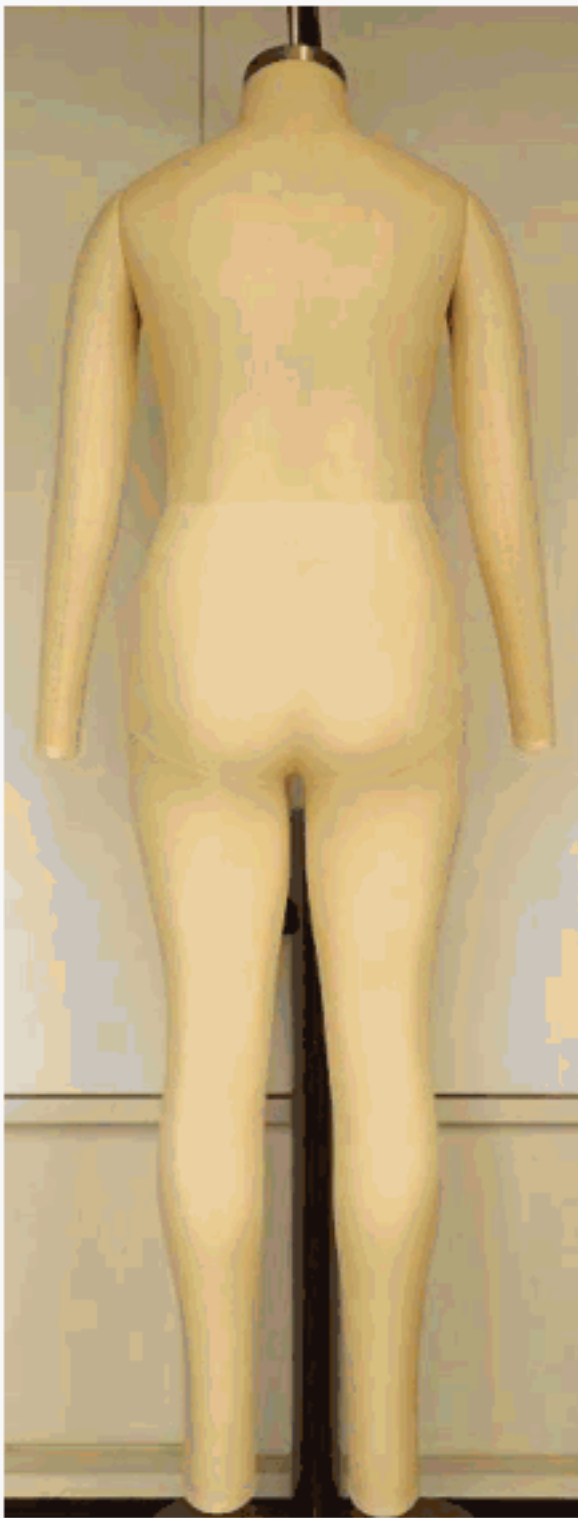


	Virtual fit mannequin model	Fit mannequin
Front view		
Back view		



Table E.3 (continued)

<p>Side view</p>		
------------------	---	--

## Bibliography

- [1] ISO 20947-2, *Performance evaluation protocol for digital fitting systems — Part 2: Virtual garment*
- [2] ISO 8559-1:2017, *Size designation of clothes — Part 1: Anthropometric definitions for body measurement*



Copyright International Organization for Standardization

