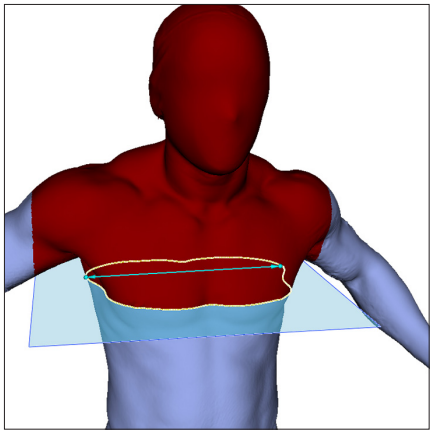
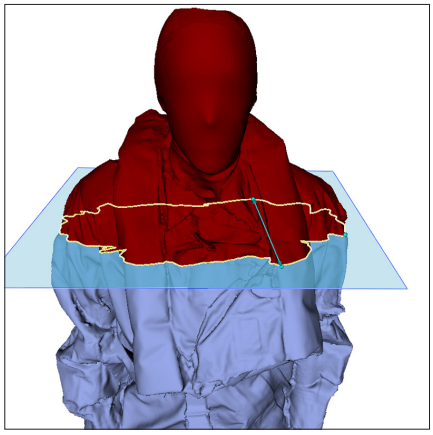
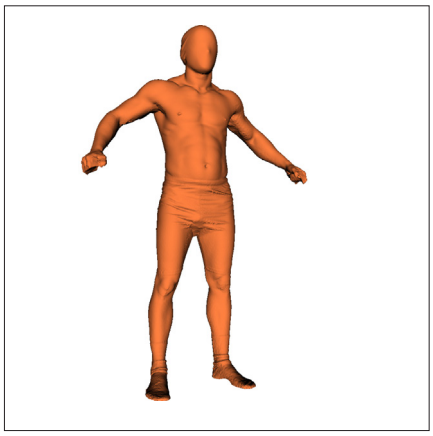
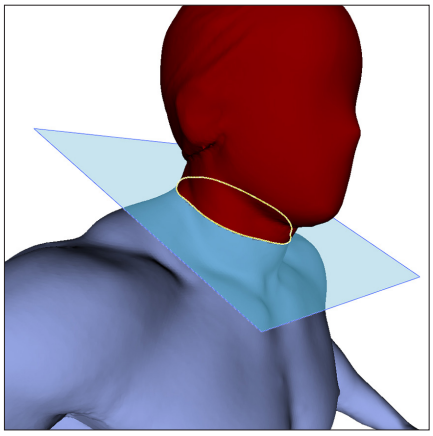


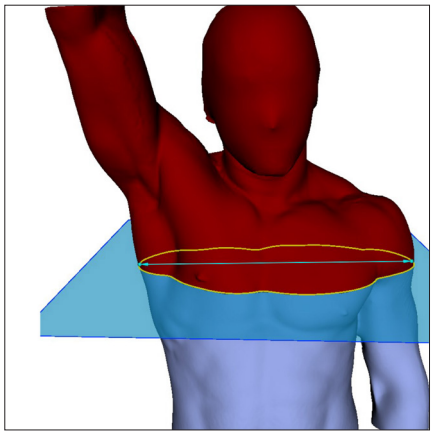



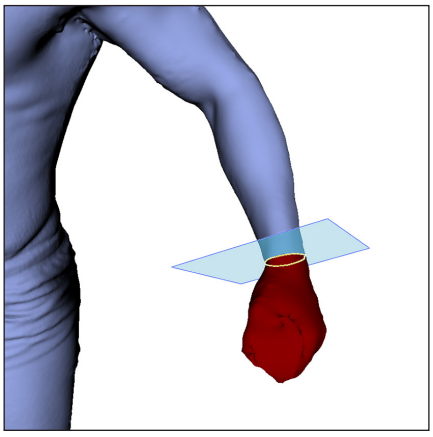
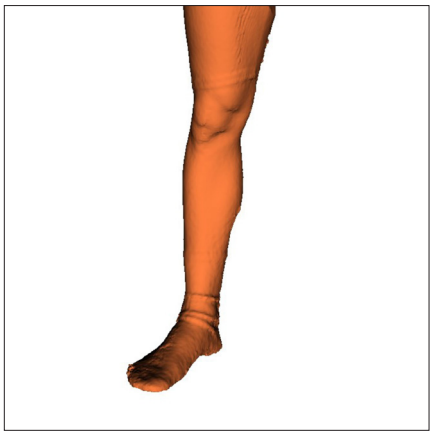
SIZE AND SHAPE OF THE UK OFFSHORE WORKFORCE 2014

Data from the 3D scanning survey

Robert Ledingham, Graham Furnace
Moira Lamb and Arthur Stewart





ROBERT GORDON UNIVERSITY ABERDEEN

Knowledge
Transfer
Partnerships

OIL&GAS UK

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We wish to thank Central Scanning for providing the scanners and technical assistance.

We wish to thank Moira Lamb for her role in scanning, logistics and liaison, Gergana Aleksandrova for processing scans, and Dr Hector Williams of RGU for statistical advice relating to imputing missing data.

Lastly we wish to thank all the volunteers who participated in the study, whose body shapes have contributed to our new data resource and sizing standard for UK offshore workers.


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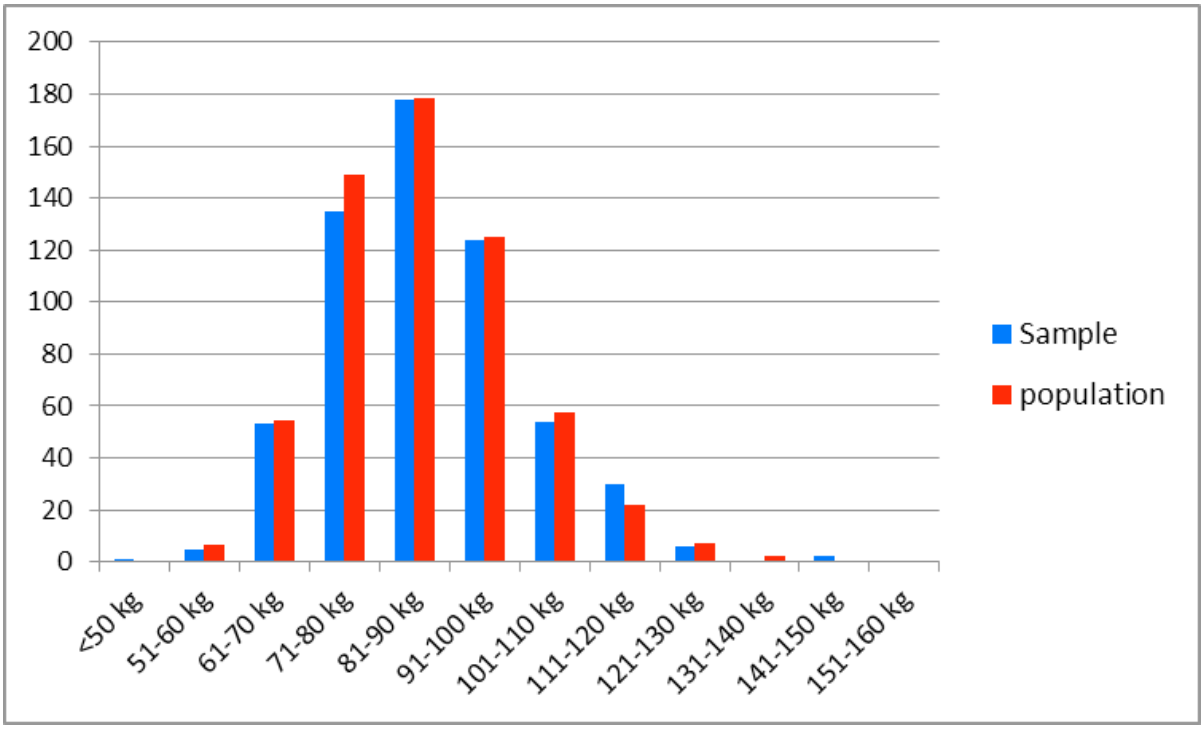
THE SAMPLE OF UK OFFSHORE WORKERS

SAMPLING

The Size and Shape of Offshore Workers Study undertook to investigate the shapes of 588 male individuals who were core crew of the UK continental shelf installations. The sample size was selected in order to be equivalent or larger than the previous study of Light and Dingwall (1985) and to enable 95% confidence to represent the true workforce weight to within 1.1 kg – a figure which can be expected with the diurnal weight fluctuation. The sample selected individuals across 7 weight categories, matched to the most reliable reference weight for the offshore workforce, collected in 2009. The illustration below depicts the frequency distribution across 10 kg weight intervals, showing a near perfect match between the selected sample and the estimate from the entire male workforce population. Chi-square value=11.7 (11 df) (P=0.613).



WEIGHT CATEGORIES

The weight categories were selected using body weight measured when wearing form-fitting clothing (lycra cycling shorts worn over participants' underwear) as follows:

category	weight range
1	< 76.4 kg
2	76.5-82.4 kg
3	82.5-87.4 kg
4	87.5-91.4 kg
5	91.5-97.4 kg
6	97.5-104.4 kg
7	> 104.5 kg

Due to the nature of scanning, taking place as individuals awaited offshore flights, it was not possible to determine in advance of participation which weight category an individual would belong to, and as a consequence, a total of 667 offshore workers were scanned. Of these, 588 were randomly selected (84 from each weight category) and the scans processed and prepared for data extraction. Of the 588, a total of 8 individuals had missing data, due to participants being called for flights before measurements were complete. These individuals were all in weight categories 5 and 6. All data corresponding to missing cells were calculated from stepwise linear regression, using the entire sample. In a total of 15 other cases, isolated cells had missing data due to incomplete scan data or artefacts introduced by clothing or movement. Taken together these imputed data represented 1.47% of the final data set.

DEMOGRAPHICS

The final sample of 588 individuals was assessed for age, stature, and weight in the three clothing assemblages.

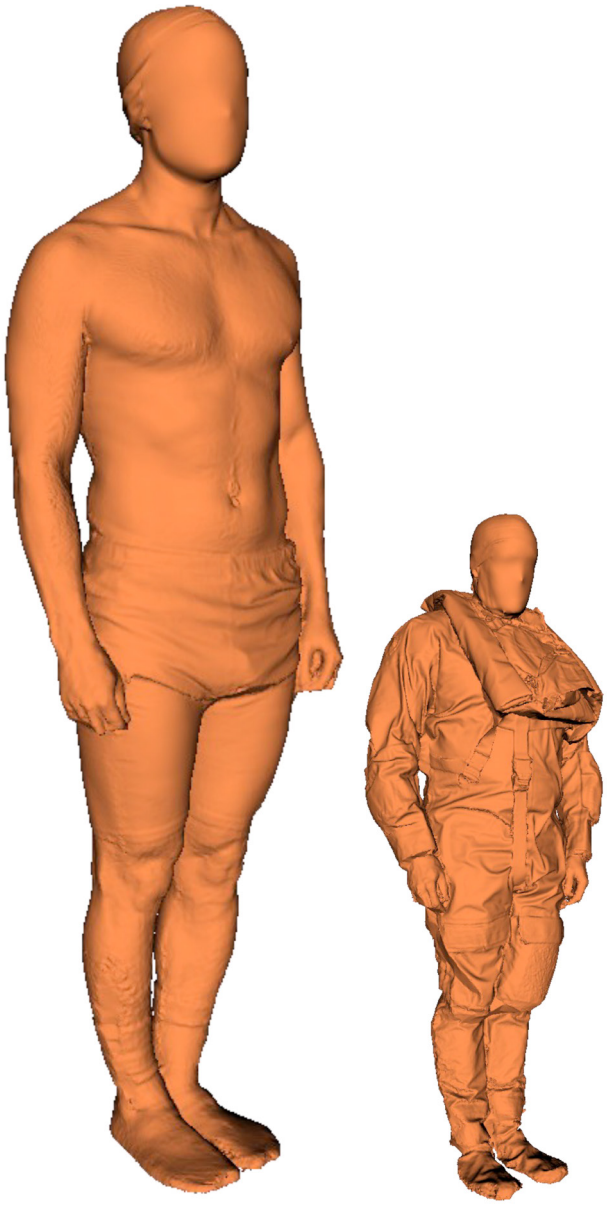
PERCENTILES

N=588	min	max	1	5	10	25	50	75	90	95	99
Age (y)	21.00	66.00	23.00	24.40	26.00	31.00	41.00	50.00	55.00	58.00	62.00
Weight in indoor clothing without shoes (kg)	52.10	150.60	64.17	71.10	74.89	82.23	91.00	99.50	110.00	117.10	129.43
Weight in survival suit and re-breather (kg)	57.50	156.70	69.66	76.55	80.39	87.73	96.50	105.15	115.83	123.09	135.18
Weight in form-fitting shorts (kg)	50.90	149.00	62.73	70.25	73.49	80.85	89.60	98.48	109.10	115.96	124.14
Stature (cm)	161.70	201.10	164.48	167.80	170.18	173.83	178.25	183.20	188.00	190.46	195.78
Body Mass Index ($kg.m^{-2}$)	18.55	45.33	20.84	22.42	23.71	25.72	27.92	30.63	33.51	35.66	39.29

THE EGRESS POSITION

This involved standing erect with the feet together and arms against the sides of the torso. The participant rested the fingers on the lateral aspect of the legs and looked straight ahead and was asked to adopt shallow breathing, to avoid movement of the thorax. In some individuals a conscious effort was required in order to hold the elbows at the sides of the torso.

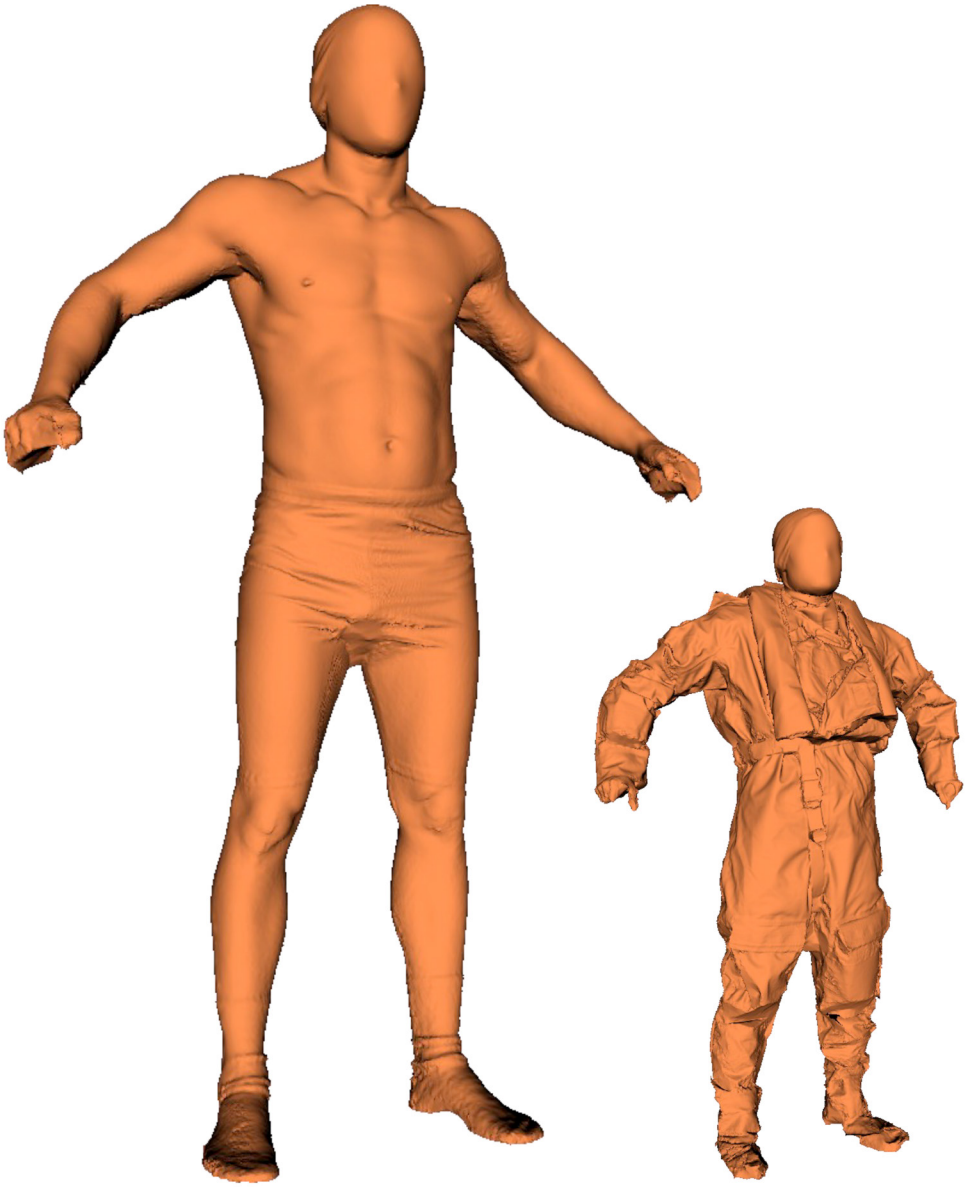
This was acquired both in survival suit and form fitting clothing.



THE SCANNER POSITION

This involved standing erect with the feet apart, and the arms abducted and elbows flexed. Four-point orthopaedic walking poles were provided to stabilise the arms and prevent body sway. The participant looked straight ahead and was asked to adopt shallow breathing to avoid movement of the thorax.

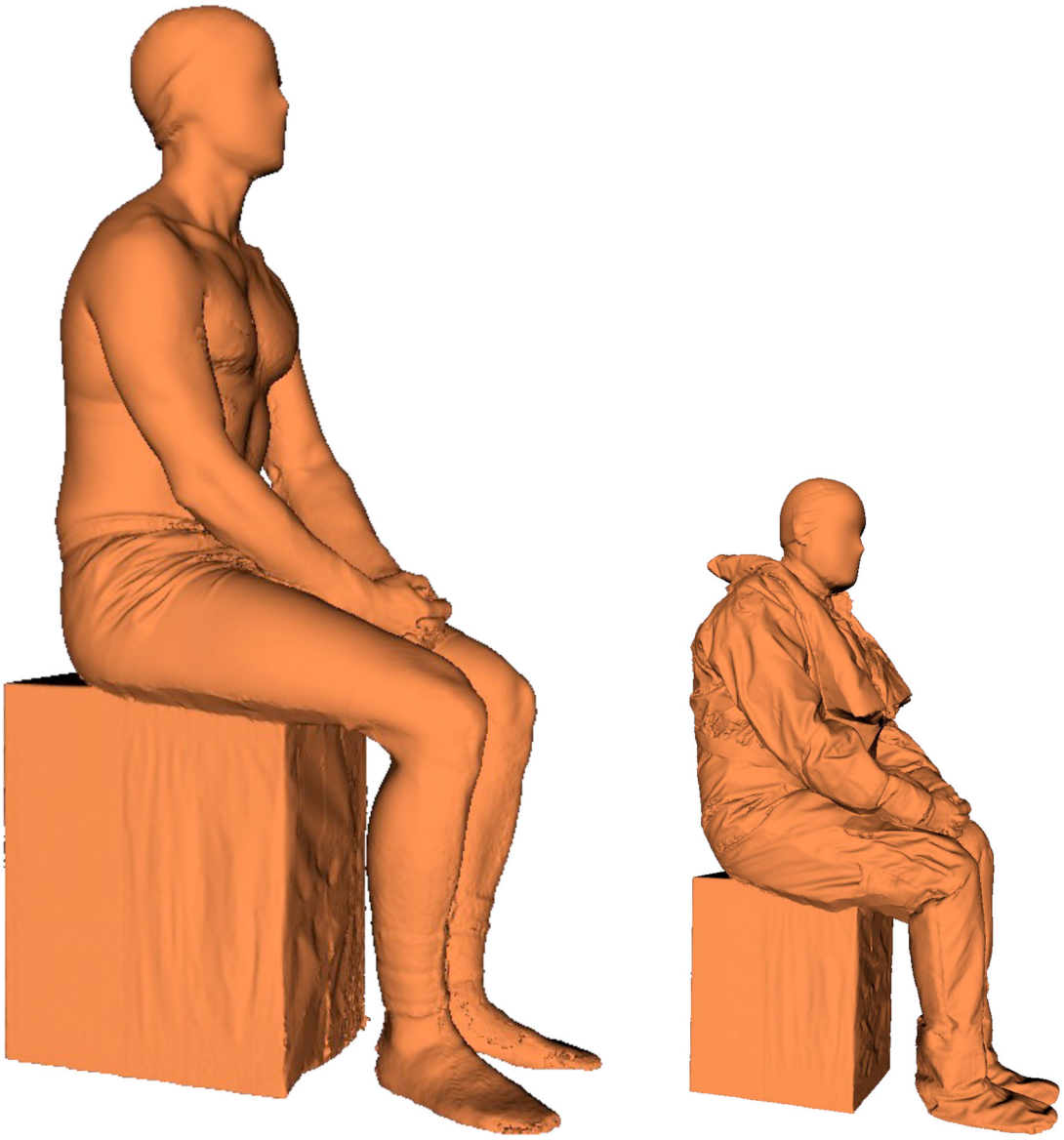
This was acquired both in survival suit and form fitting clothing.



THE SEATED POSITION

This involved sitting on a horizontal surface with the knees together and flexed to a right angle, and with hands together on the lap. The subject looked straight ahead and was asked to adopt shallow breathing, to avoid movement of the thorax.

This was acquired both in survival suit and form fitting clothing.

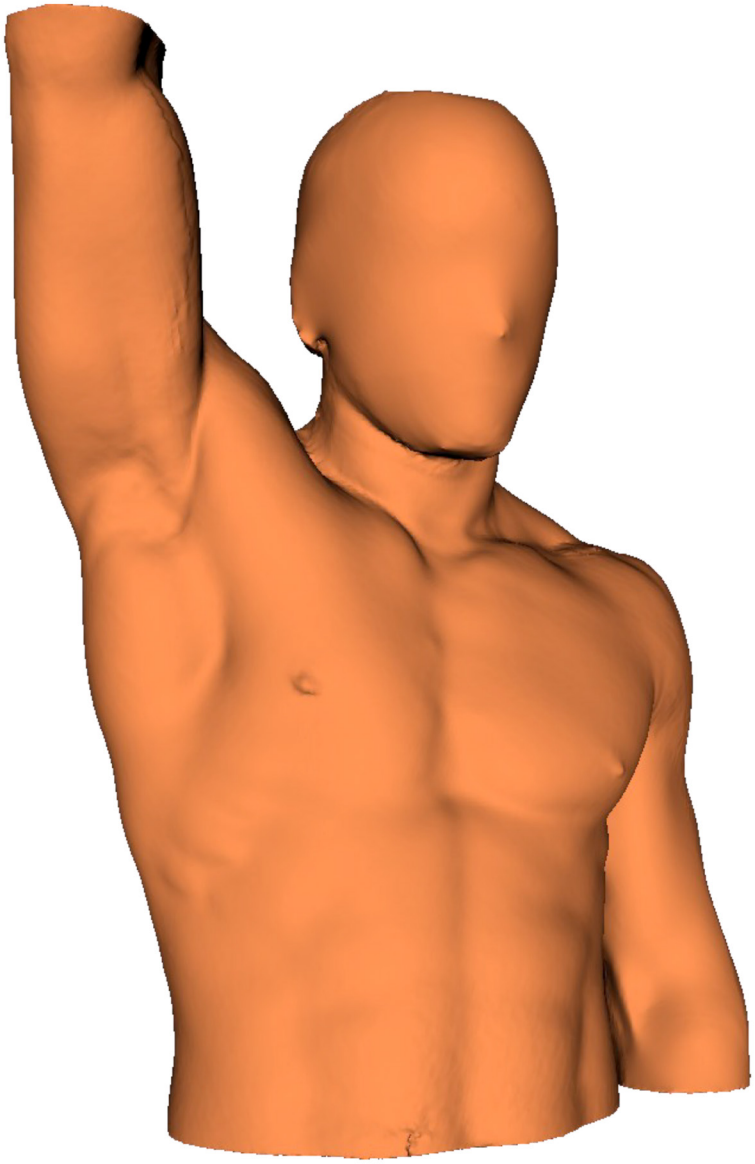


THE RAISED ARM POSITION

This involved a torso scan of the standing body, when one arm is raised above the head.

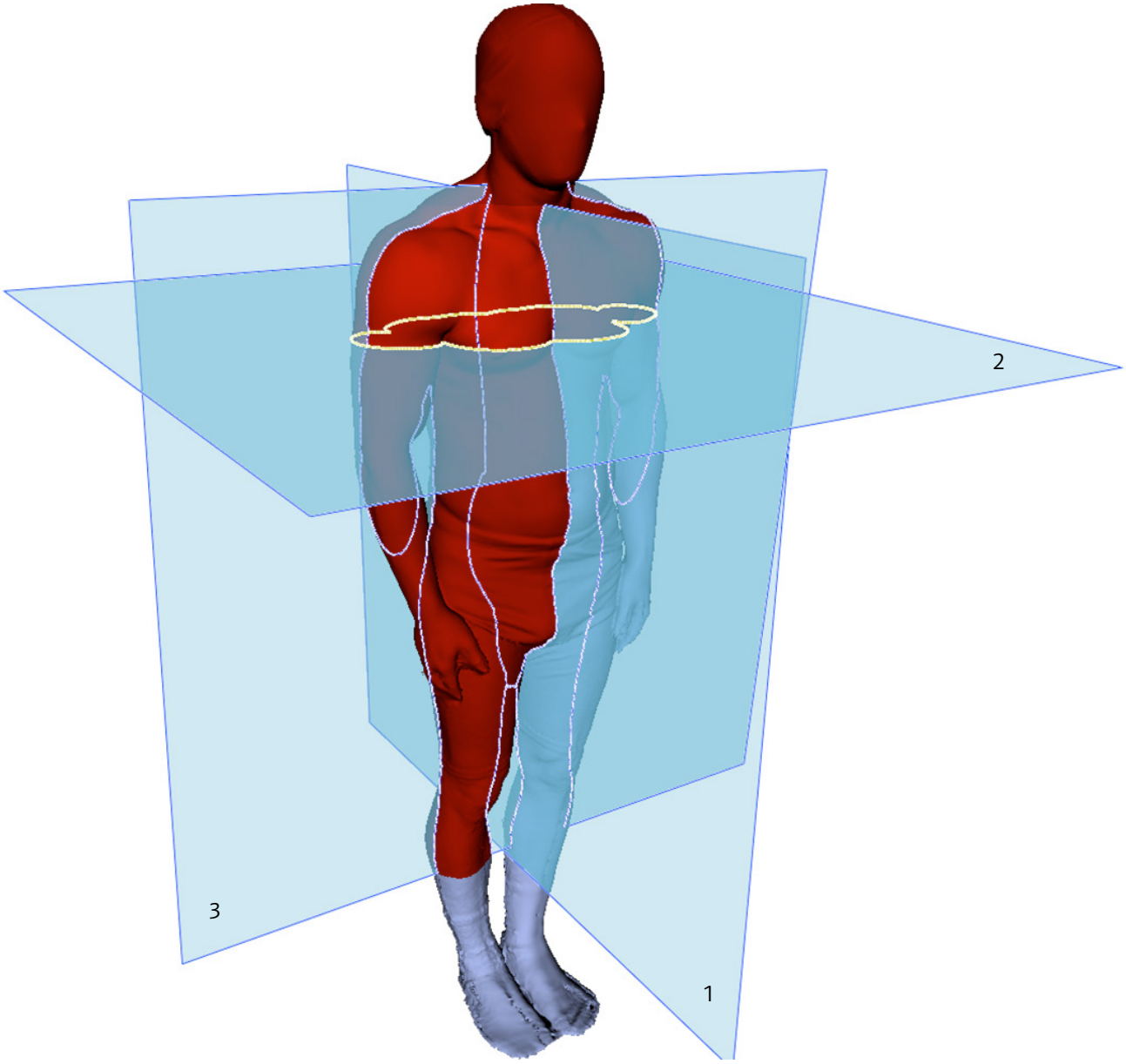
The participant looked straight ahead and was asked to adopt shallow breathing, to avoid movement of the thorax.

This was acquired in form fitting clothing only, and only on 405 individuals.



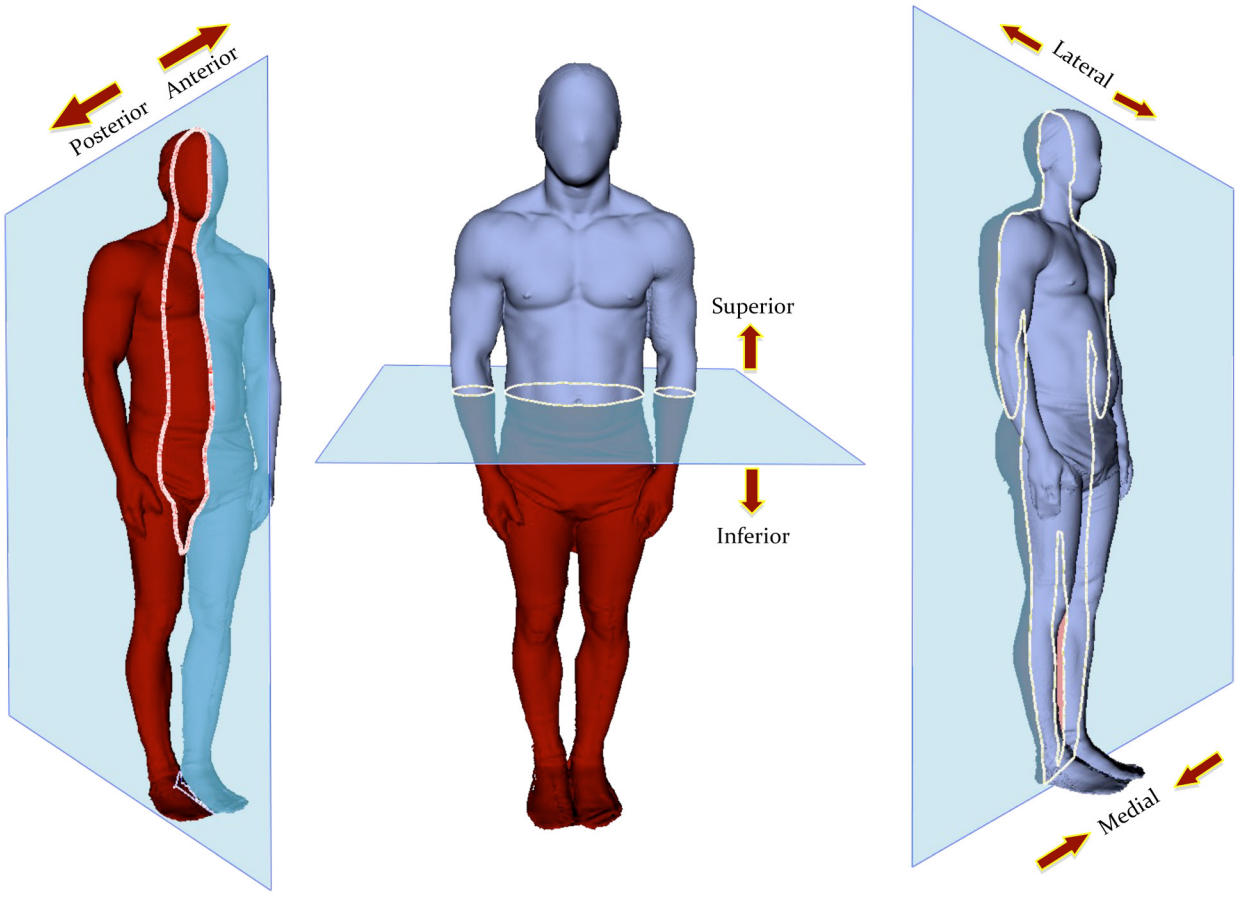
DIRECTIONAL TERMINOLOGY DESCRIBING MEASUREMENTS

Before defining measurements to extract, it is important to be sure of the directional terminology associated with anatomy. Key axes and planes are described below, so that measurement definitions may be better understood.



The sagittal (1), transverse (2) and coronal (or frontal) plane (3)

DIRECTIONAL TERMINOLOGY DESCRIBING MEASUREMENTS



PRIMARY MEASURES EXTRACTED

	MEASUREMENT	POSITION; CLOTHING ASSEMBLAGE
1	Shoulder girth	Egress Form
2	Bideltoid breadth	Egress Form
3	Deltoid height	Egress Form
4	Chest depth at deltoid	Egress Form
5	Max chest depth	Egress Form
6	Neck girth	Egress Form
7	Chest depth at deltoid	Egress Survival Suit
8	Max depth	Egress Survival Suit
9	Max breadth	Egress Survival Suit
10	Chest breadth (axilla)	Scanner Form
11	Chest girth (nipple)	Scanner Form
12	Chest breadth (nipple)	Scanner Form
13	Waist girth (min)	Scanner Form
14	Waist girth (umbilicus)	Scanner Form
15	Abdominal depth	Scanner Form
16	Hip girth	Scanner Form
17	Hip breadth	Scanner Form
18	Wrist girth	Scanner Form
19	Total volume	Scanner Form

	MEASUREMENT	POSITION; CLOTHING ASSEMBLAGE
20	Torso volume	Scanner Form
21	Arm volume	Scanner Form
22	Leg volume	Scanner Form
23	Total volume (SS)	Scanner Survival Suit
24	Hip Breadth	Sitting Form
25	Buttock to knee	Sitting Form
26	Deltoid to thorax	Raised arm

VARIABLES SELECTED

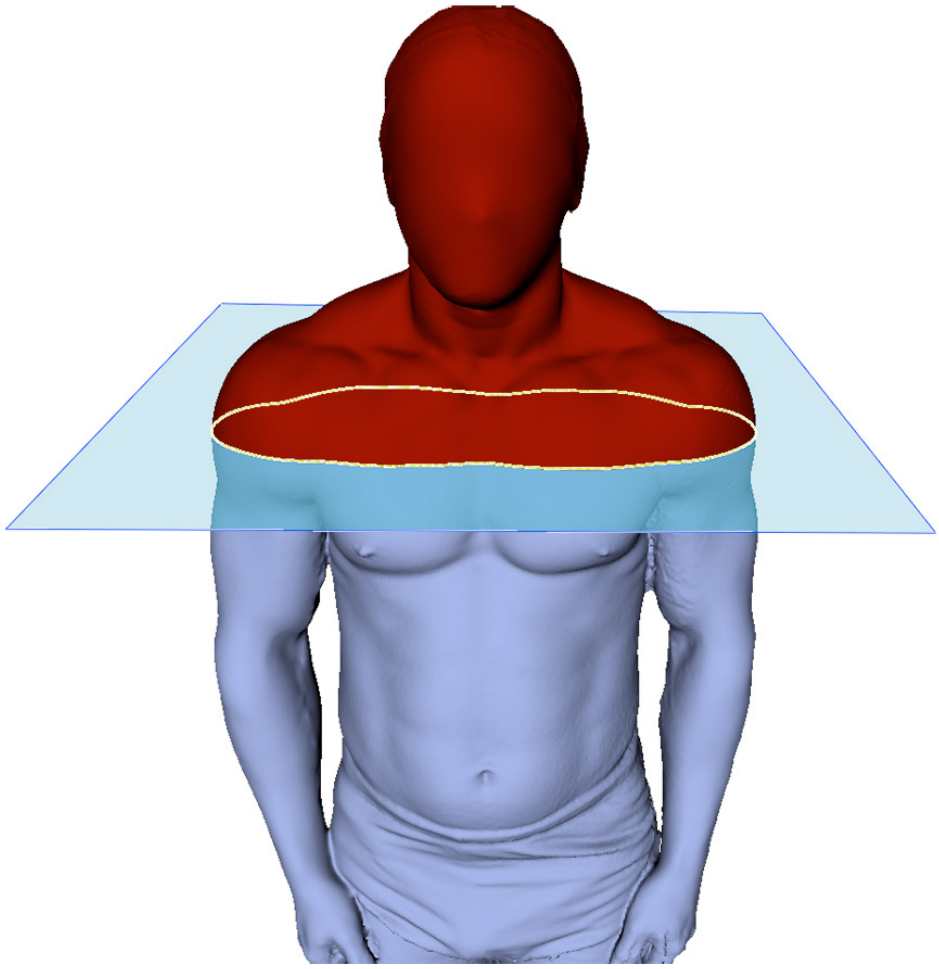
The selection of variables was designed to balance the utility of certain key measures, with the time taken to extract measurements, and also the ability to compare with previous data sets. After close examination, and careful consideration, it was decided to exclude crotch height from the data set, because the artefacts introduced in this region due to post scan processing, which artificially 'webbed' the crotch region as a result of the application of smoothing and hole-filling algorithms which were integral to the analysis software.

1. SHOULDER GIRTH

SUBJECT POSITION: EGRESS

DEFINITION

The linear distance along the perimeter of the transverse section identified for the maximal bideltoid breadth.



PERCENTILES

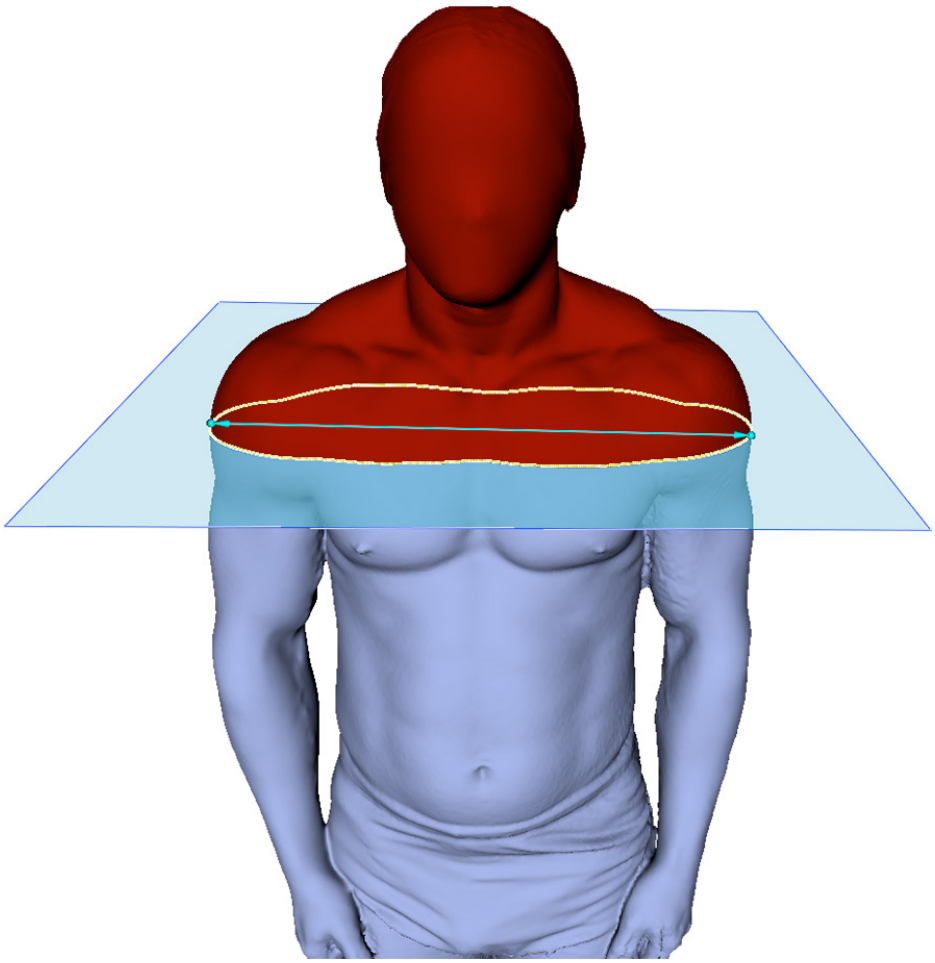
N=588	min	max	1	5	10	25	50	75	90	95	99
Shoulder girth (cm)	103.99	159.52	111.26	116.42	118.68	123.74	129.23	134.66	140.50	144.40	155.74

2. BIDELTOID BREADTH

SUBJECT POSITION: EGRESS

DEFINITION

The linear distance between the most lateral points on the skin surface at the R and L deltoid muscles.



PERCENTILES

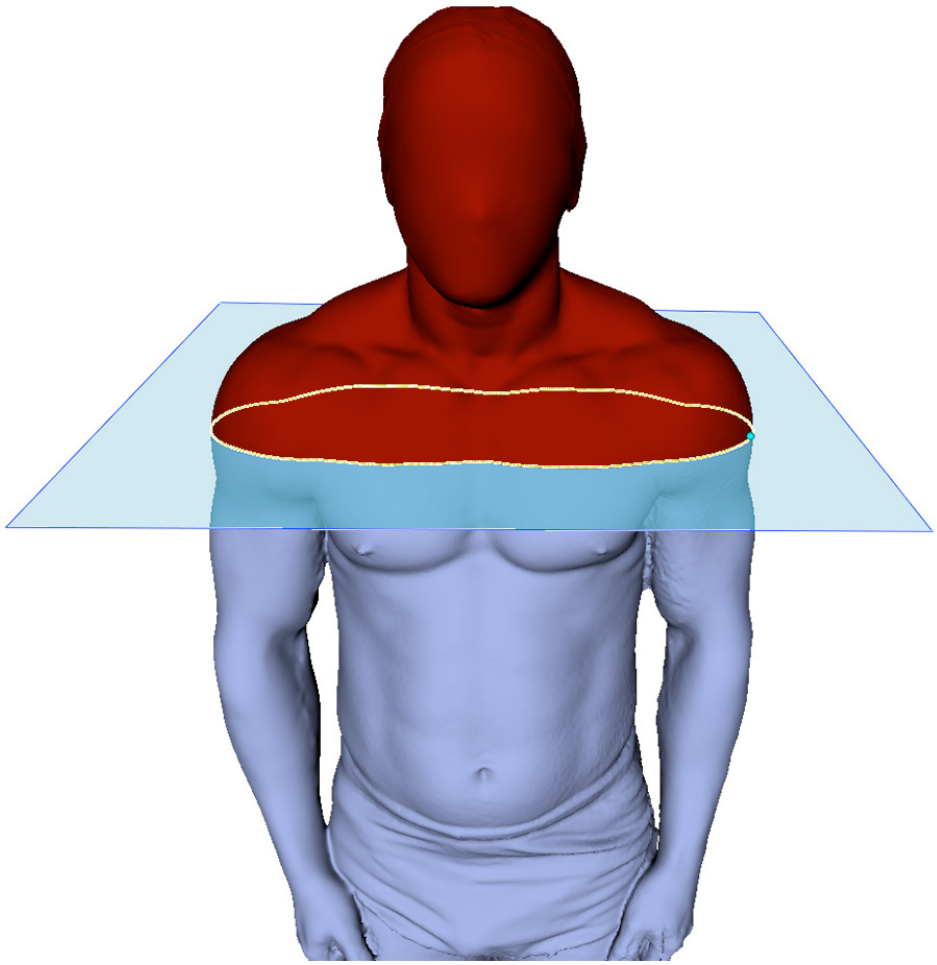
N=588	min	max	1	5	10	25	50	75	90	95	99
Bideltoid Breadth (cm)	42.23	64.60	45.14	47.18	48.10	49.77	51.78	53.81	55.81	57.23	59.70

3. DELTOID HEIGHT

SUBJECT POSITION: EGRESS

DEFINITION

The vertical distance of the lateral and inferior aspect of the deltoid from the standing surface.



PERCENTILES

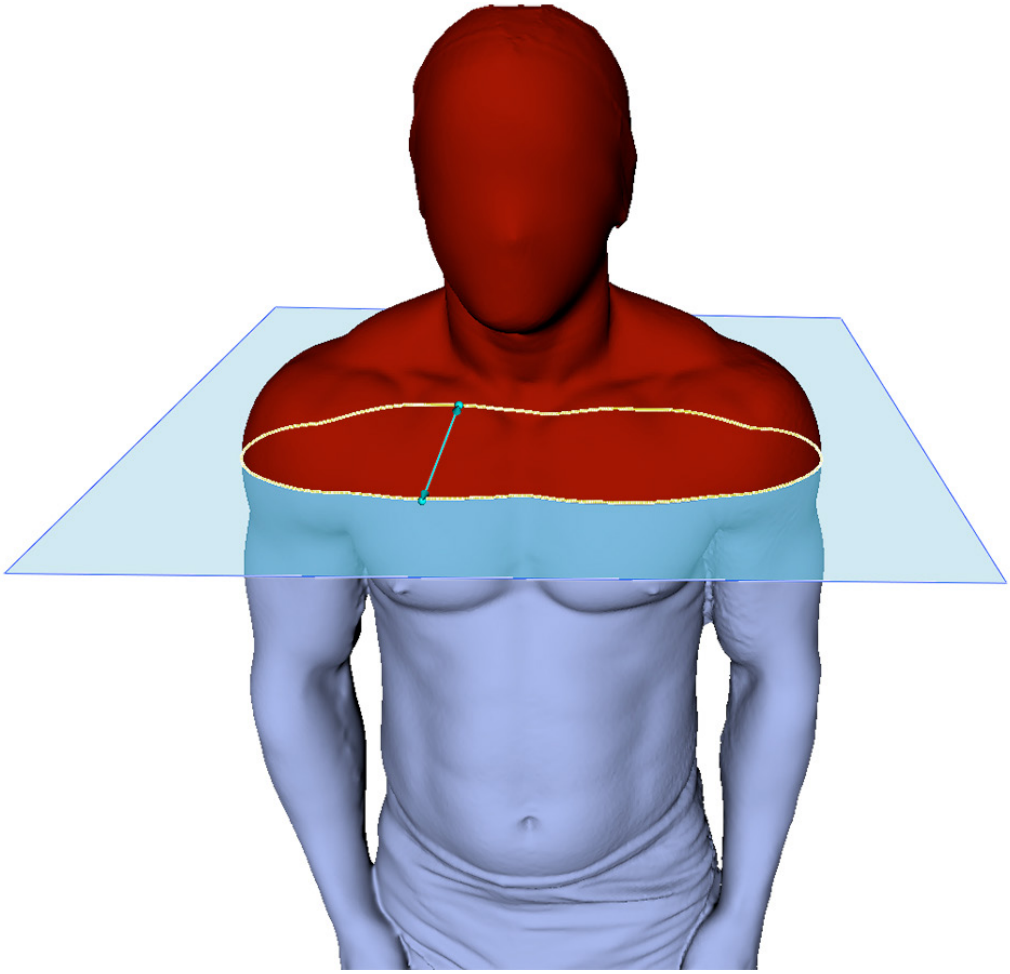
N=588	min	max	1	5	10	25	50	75	90	95	99
Deltoid height (cm)	117.81	153.32	123.10	125.40	127.54	130.79	134.69	139.16	142.97	144.97	150.21

4. CHEST DEPTH AT DELTOID (FORM)

SUBJECT POSITION: EGRESS

DEFINITION

The horizontal distance in a sagittal plane between the most anterior and most posterior points on a transverse plane drawn at the most lateral and inferior aspect of the deltoid muscle.



PERCENTILES

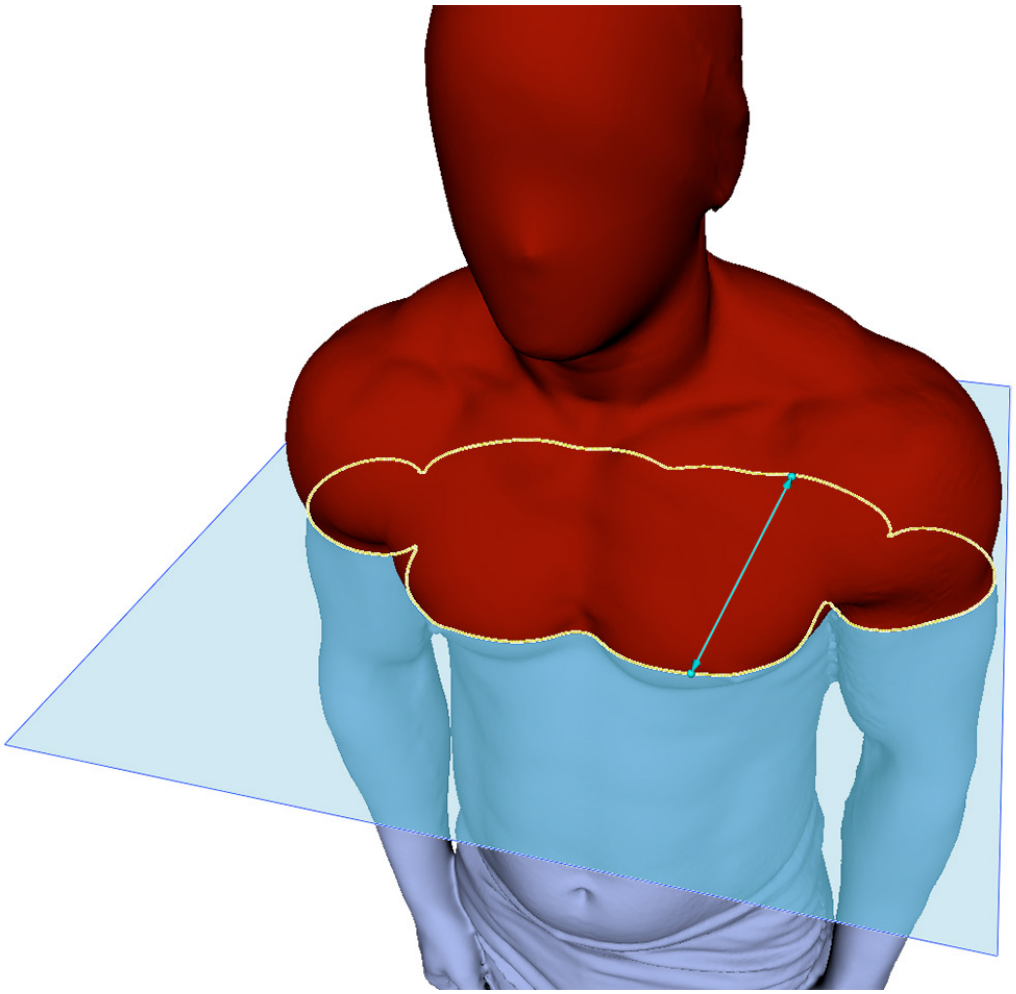
N=588	min	max	1	5	10	25	50	75	90	95	99
Chest depth at deltoid (cm)	19.19	35.10	20.80	22.39	23.20	24.49	26.13	27.75	29.54	31.08	32.63

5. MAXIMUM THORAX DEPTH (FORM)

SUBJECT POSITION: EGRESS

DEFINITION

The horizontal distance in a sagittal plane between the most anterior and most posterior points on a transverse plane drawn at the maximum anterior extension of the thorax.



PERCENTILES

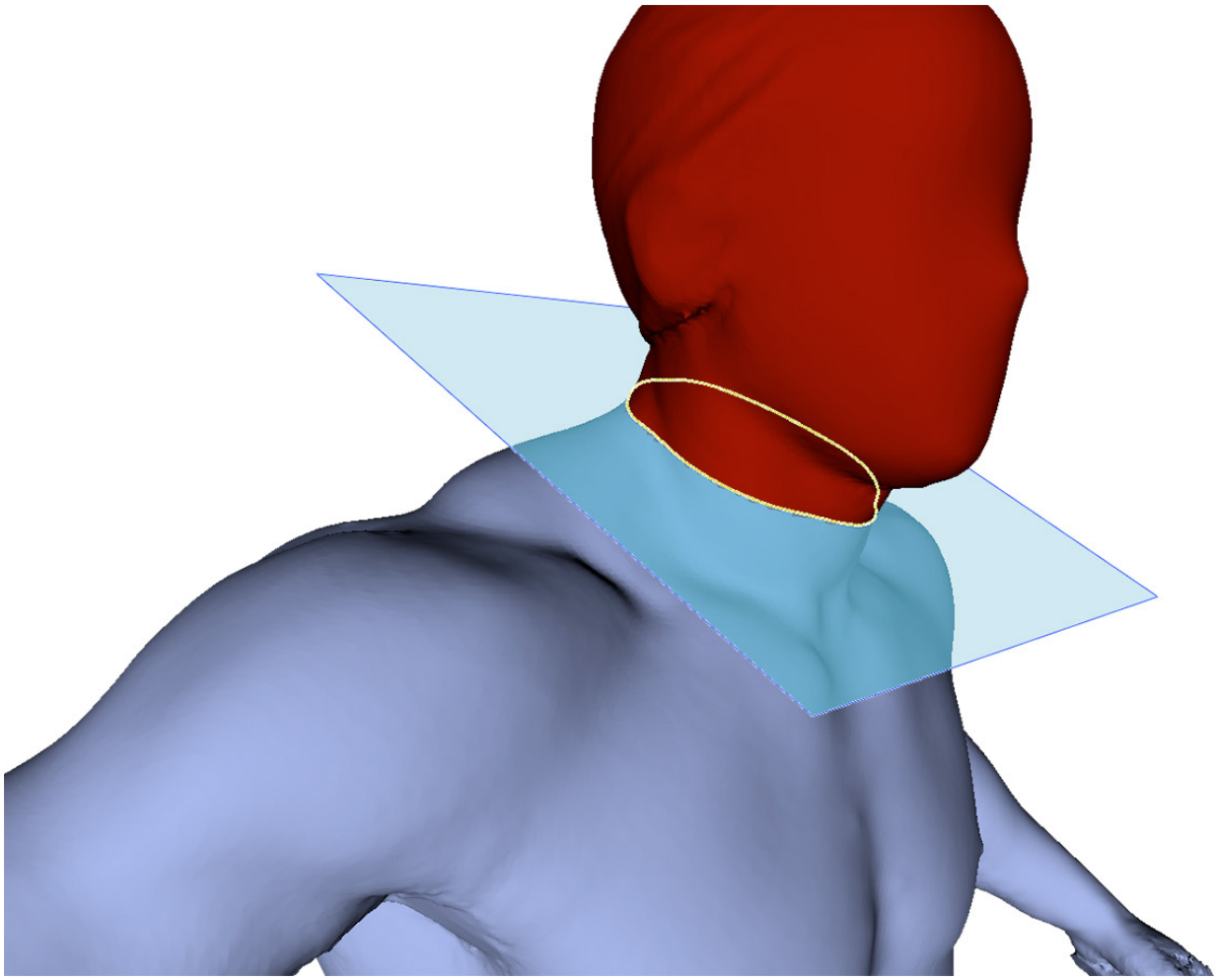
N=588	min	max	1	5	10	25	50	75	90	95	99
Maximum thorax depth (cm)	20.83	37.10	22.09	23.61	24.65	26.41	28.06	30.17	31.99	33.16	35.38

6. NECK GIRTH

SUBJECT POSITION: EGRESS

DEFINITION

The circumference of an oblique plane perpendicular to the long axis of the neck, inferior to the Adam's apple.



PERCENTILES

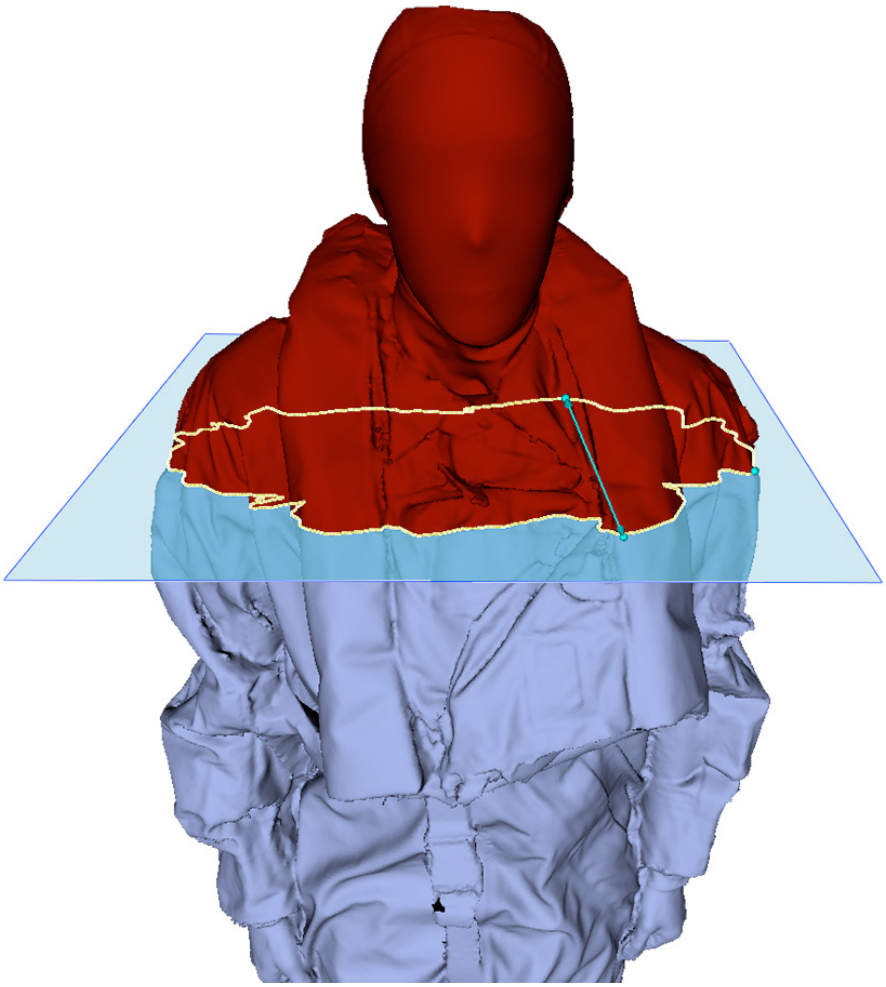
N=588	min	max	1	5	10	25	50	75	90	95	99
Neck girth (cm)	34.91	52.22	36.09	37.50	38.28	39.91	41.88	43.83	46.27	47.67	50.91

7. CHEST DEPTH AT DELTOID (SURVIVAL SUIT)

SUBJECT POSITION: EGRESS

DEFINITION

The horizontal distance in a sagittal plane between the most anterior and most posterior points on a transverse plane drawn at the deltoid height.



PERCENTILES

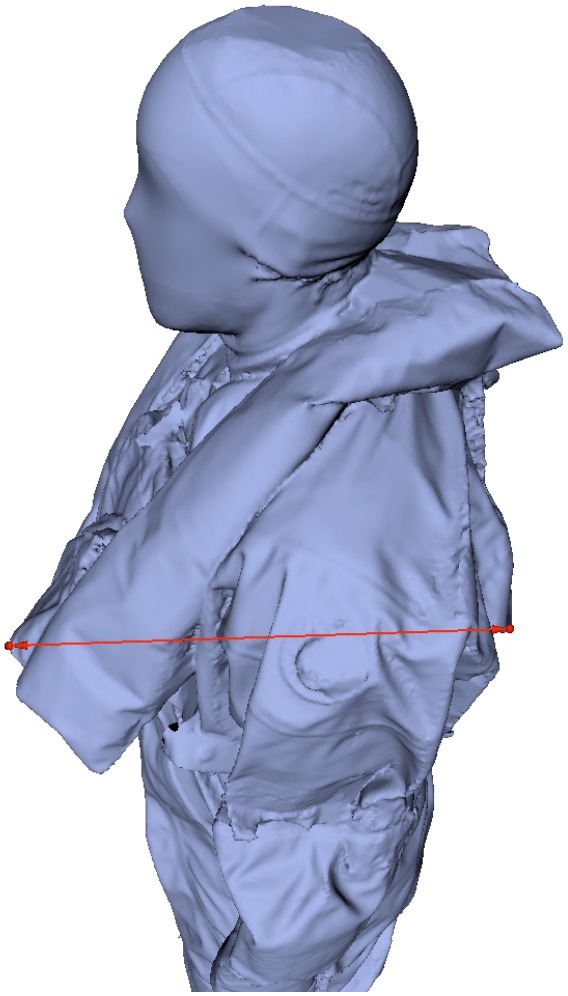
N=588	min	max	1	5	10	25	50	75	90	95	99
Chest depth at deltoid in Survival Suit	30.73	55.47	33.53	34.51	35.19	36.57	38.26	39.95	41.37	42.75	46.14

8. MAXIMUM DEPTH (SURVIVAL SUIT)

SUBJECT POSITION: EGRESS

DEFINITION

The horizontal distance in a sagittal plane between the most anterior and most posterior points on a transverse plane drawn at the maximum anterior extension of the thorax.



PERCENTILES

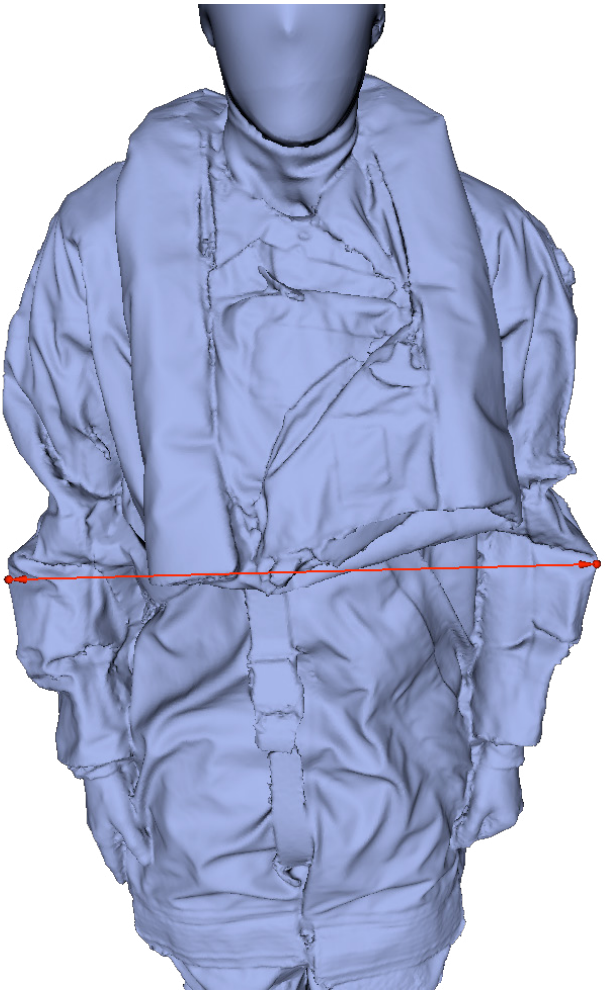
N=588	min	max	1	5	10	25	50	75	90	95	99
Maximal depth in Survival Suit (cm)	35.58	56.21	39.09	41.71	42.70	44.59	46.43	48.07	49.48	50.36	53.09

9. MAXIMAL BREADTH (SURVIVAL SUIT)

SUBJECT POSITION: EGRESS

DEFINITION

The maximum horizontal distance across the scanned figure in the coronal plane.



PERCENTILES

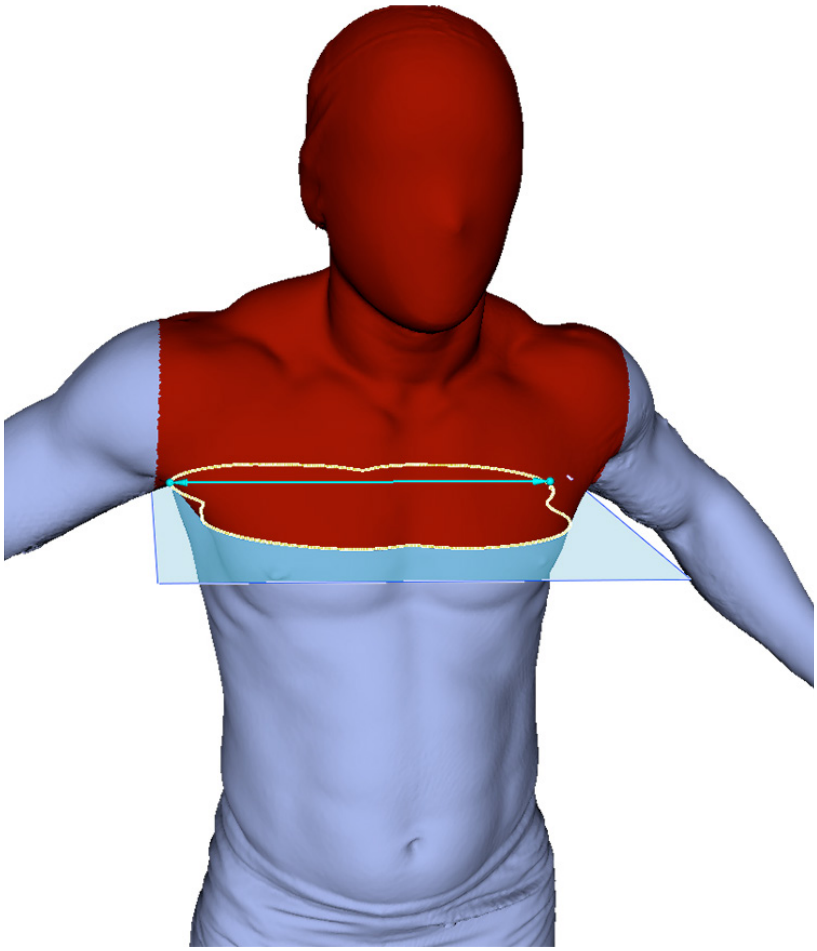
N=588	min	max	1	5	10	25	50	75	90	95	99
Maximal breadth in Survival Suit (cm)	49.87	80.62	61.78	64.07	64.91	66.67	68.93	71.39	73.28	74.36	76.85

10. CHEST BREADTH (AXILLA)

SUBJECT POSITION: SCANNER

DEFINITION

The horizontal distance in a transverse plane between the most lateral points on the thorax, at the level of the axilla.



PERCENTILES

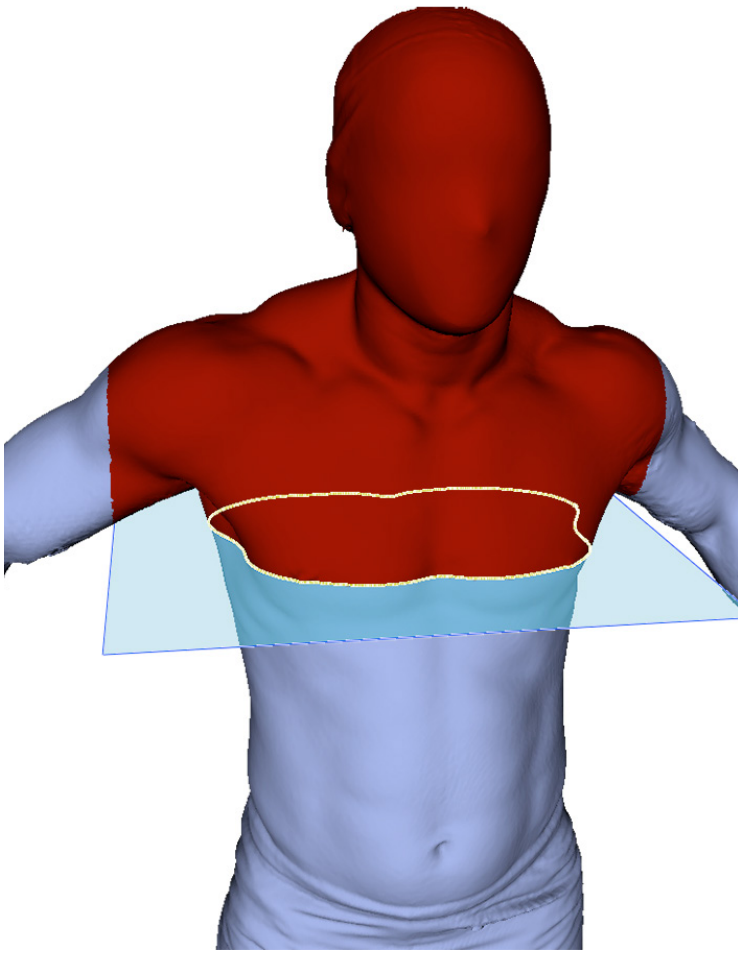
N=588	min	max	1	5	10	25	50	75	90	95	99
Chest breadth at axila (cm)	30.11	49.56	33.47	35.05	36.26	37.63	39.51	41.33	42.92	44.07	46.54

11. CHEST GIRTH (NIPPLE)

SUBJECT POSITION: SCANNER

DEFINITION

The circumference of the thorax at the level of the nipple.



PERCENTILES

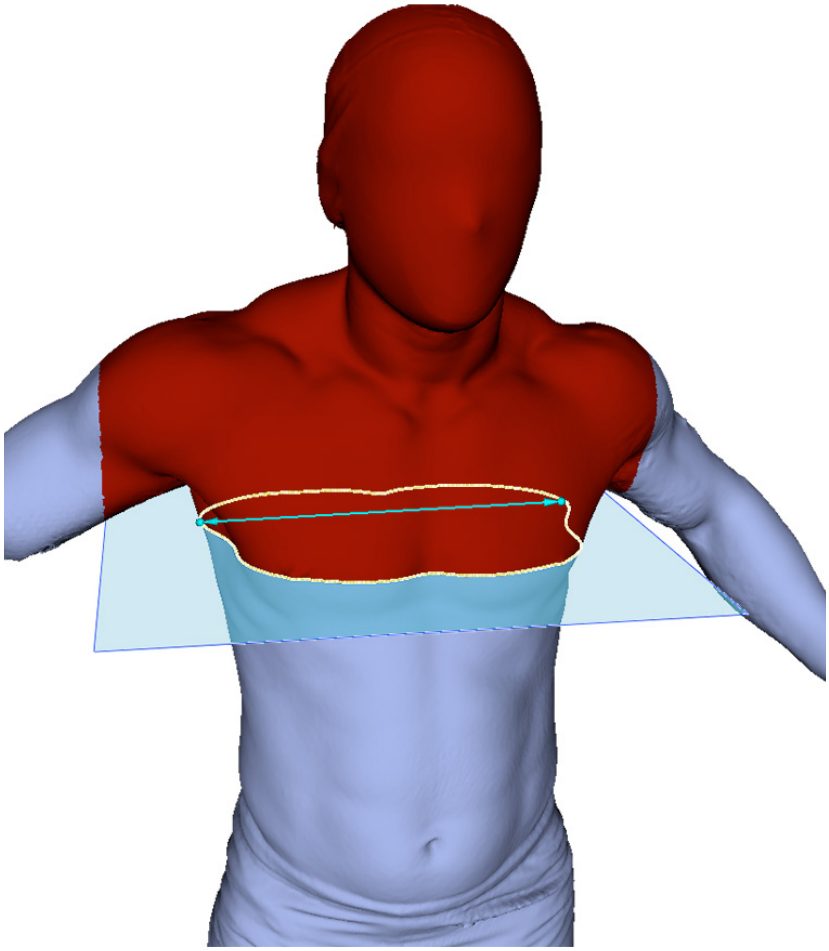
N=588	min	max	1	5	10	25	50	75	90	95	99
Chest girth at nipple (cm)	84.19	137.11	88.28	92.50	95.86	100.84	106.69	113.54	119.53	123.19	129.99

12. CHEST BREADTH (NIPPLE)

SUBJECT POSITION: SCANNER

DEFINITION

The horizontal distance in a transverse plane between the most lateral points on the thorax at the level of the nipple.



PERCENTILES

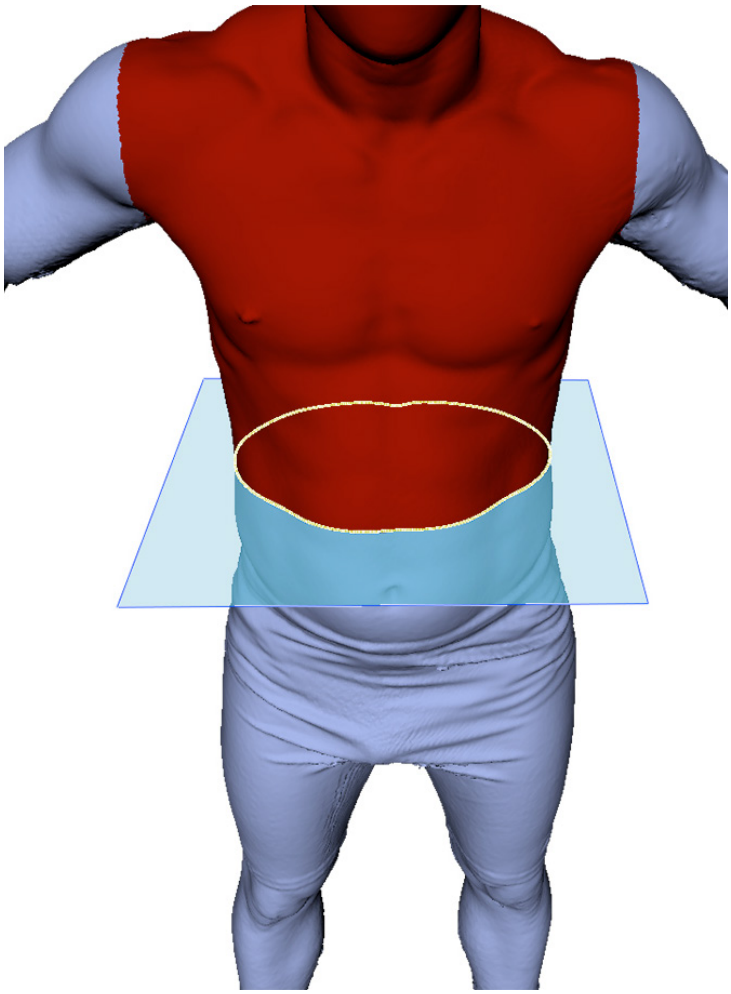
N=588	min	max	1	5	10	25	50	75	90	95	99
Chest breadth at nipple (cm)	29.32	47.66	30.53	32.14	33.19	34.82	36.39	38.68	40.89	42.10	44.68

13. WAIST GIRTH (MINIMUM)

SUBJECT POSITION: SCANNER

DEFINITION

The minimum distance around the waist which is measured on a transverse section superior to the iliac crest and inferior to the 10th rib.



PERCENTILES

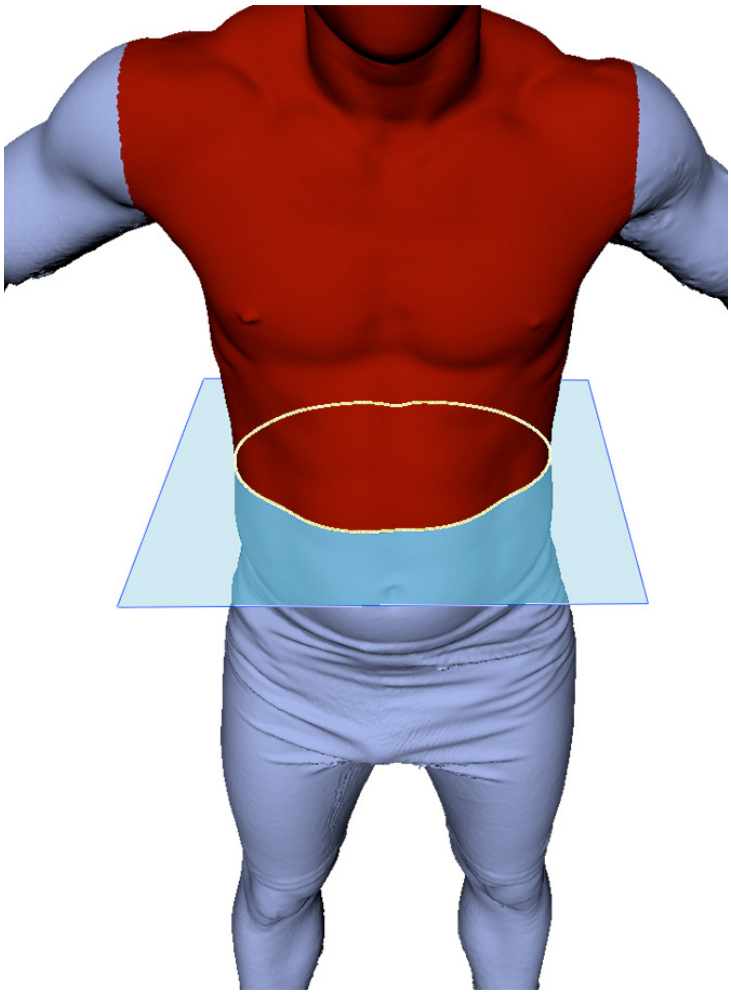
N=588	min	max	1	5	10	25	50	75	90	95	99
Waist girth minimum (cm)	68.39	140.54	76.68	81.51	84.79	90.04	97.27	105.21	112.11	117.44	124.70

14. WAIST GIRTH (UMBILICUS)

SUBJECT POSITION: SCANNER

DEFINITION

The distance around the waist which is measured on a transverse section at the level of the umbilicus.



PERCENTILES

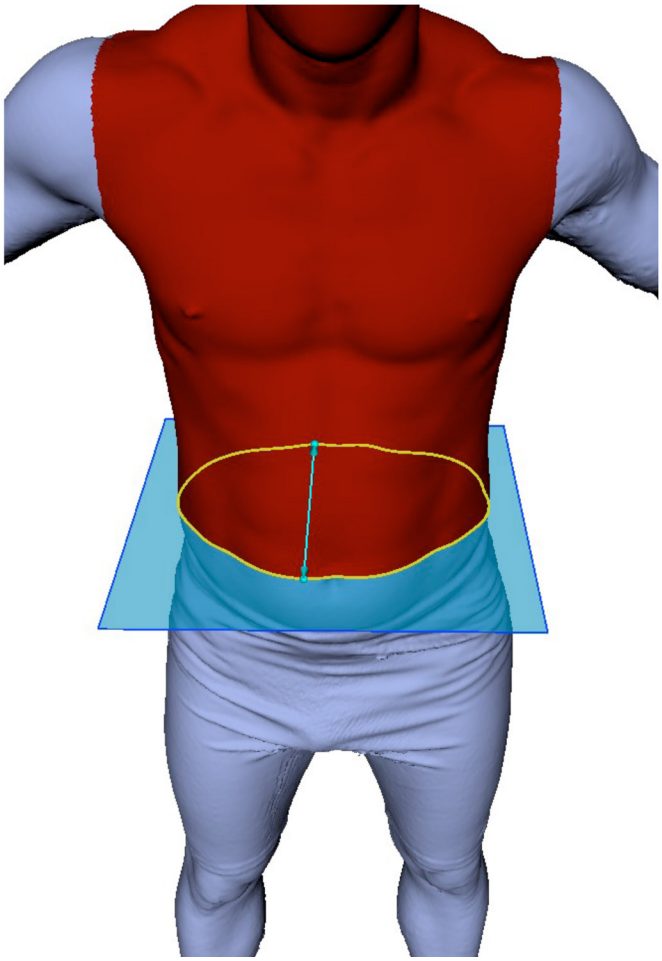
N=588	min	max	1	5	10	25	50	75	90	95	99
Waist girth at umbilicus (cm)	72.31	141.34	78.67	85.87	88.43	94.89	102.23	109.08	117.25	122.13	135.70

15. ABDOMINAL DEPTH

SUBJECT POSITION: SCANNER

DEFINITION

On a transverse plane at the level of the midpoint of the umbilicus,
the distance in a sagittal plane between the most anterior and most posterior points.



PERCENTILES

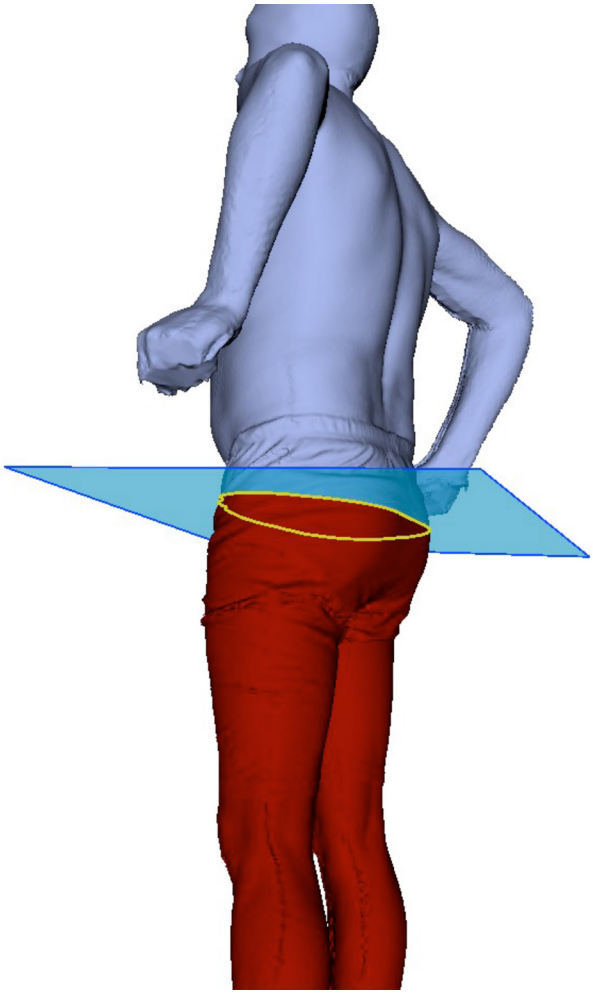
N=588	min	max	1	5	10	25	50	75	90	95	99
Abdominal depth (cm)	17.28	40.90	19.65	21.46	22.50	24.27	27.01	29.82	32.51	34.44	37.98

16. HIP GIRTH

SUBJECT POSITION: SCANNER

DEFINITION

The distance around the hips in a transverse plane at the level of the greatest posterior protuberance of the buttocks.



PERCENTILES

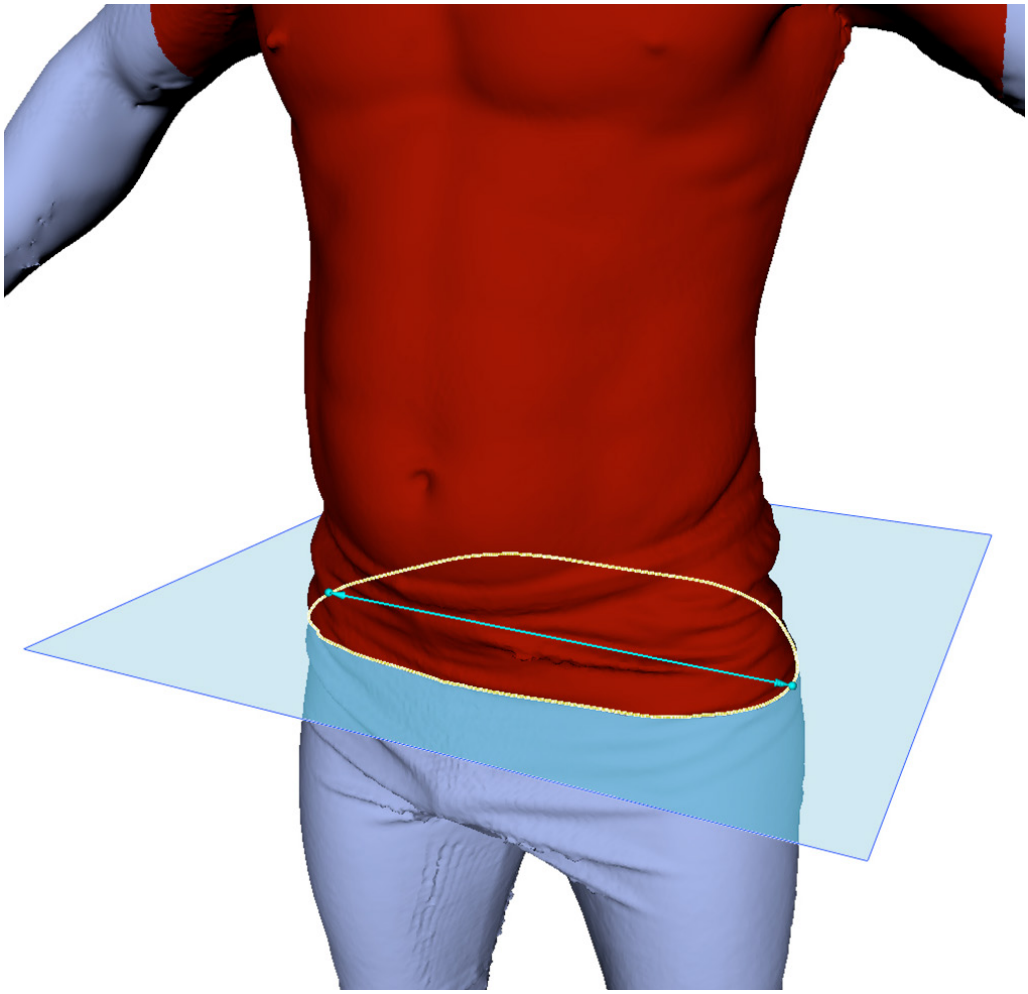
N=588	min	max	1	5	10	25	50	75	90	95	99
Hip girth (cm)	85.83	140.97	91.84	95.88	97.68	100.71	105.29	110.05	114.71	117.26	126.30

17. HIP BREADTH (STANDING)

SUBJECT POSITION: SCANNER

DEFINITION

The horizontal distance in a transverse plane between the most lateral points on the section at the level of greatest posterior protuberance of the buttocks.



PERCENTILES

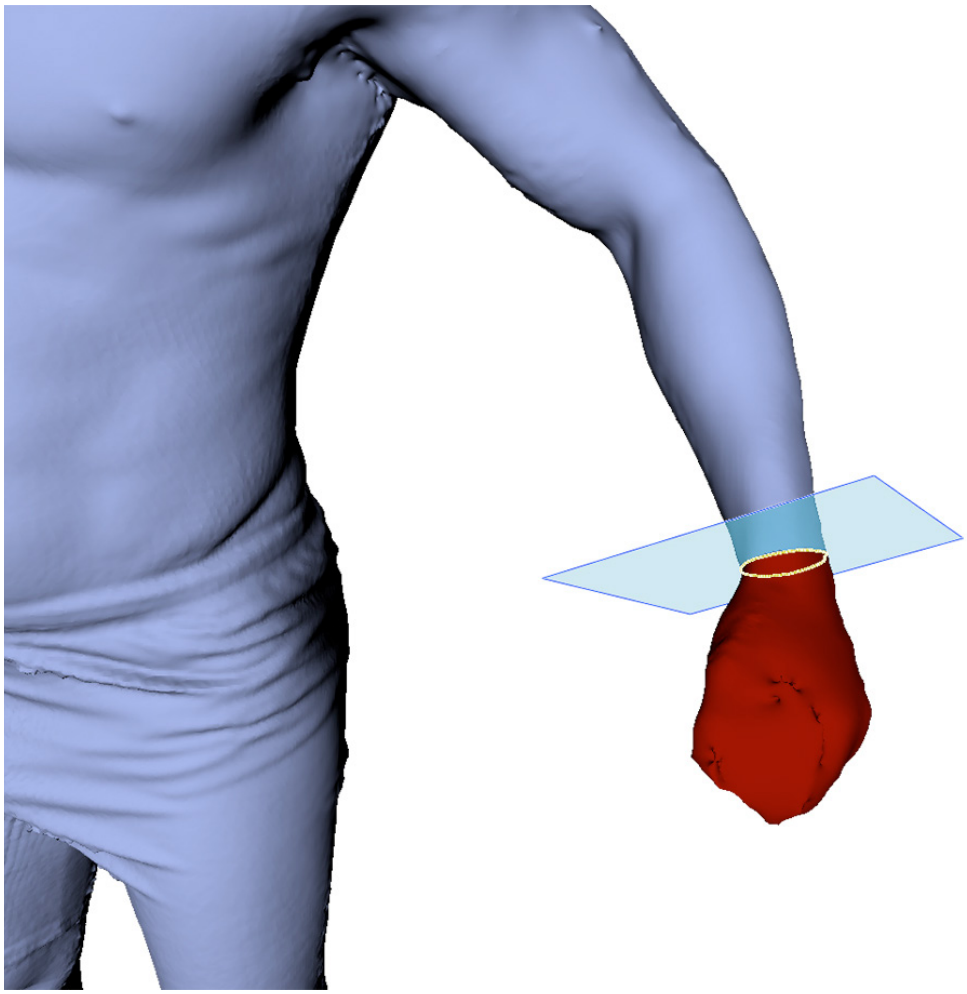
N=588	min	max	1	5	10	25	50	75	90	95	99
Hip breadth (cm)	31.49	49.08	33.18	34.41	35.02	36.09	37.53	38.99	40.48	41.39	43.59

18. WRIST GIRTH

SUBJECT POSITION: SCANNER

DEFINITION

The minimum circumference of the wrist.



PERCENTILES

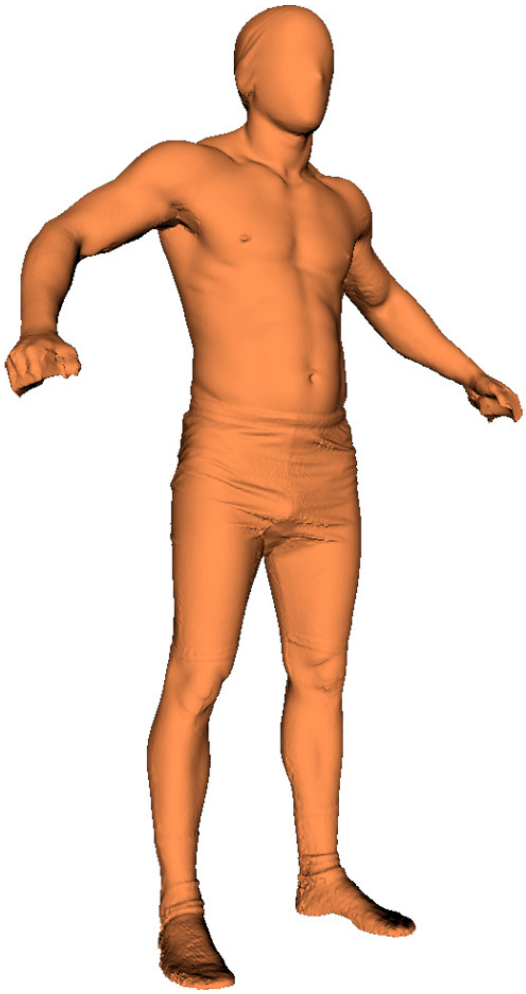
N=588	min	max	1	5	10	25	50	75	90	95	99
Wrist girth (cm)	15.41	23.63	15.84	16.58	17.02	17.79	18.71	19.71	20.77	21.20	22.37

19. TOTAL VOLUME (FORM)

SUBJECT POSITION: SCANNER

DEFINITION

The volume of the body.



PERCENTILES

N=588	min	max	1	5	10	25	50	75	90	95	99
Total volume (l)	53.33	156.32	64.21	71.94	75.28	81.26	90.47	99.70	110.54	117.37	129.40

20. TORSO VOLUME

SUBJECT POSITION: SCANNER

DEFINITION

The volume of the torso, excluding the arms, legs and head.

PERCENTILES

N=588	min	max	1	5	10	25	50	75	90	95	99
Torso volume (l)	29.24	96.05	32.94	37.31	40.17	44.26	49.43	56.31	64.96	69.29	77.79

21. ARM VOLUME

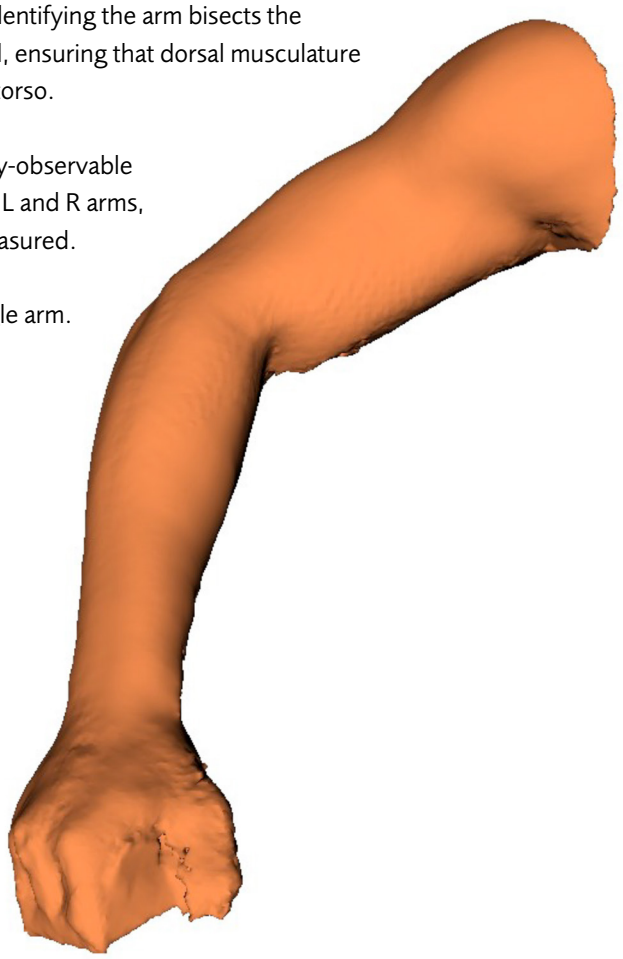
SUBJECT POSITION: SCANNER

DEFINITION
The volume of the arm.

NOTES
1. The cut-line for identifying the arm bisects the gleno-humeral head, ensuring that dorsal musculature remains part of the torso.

2. If there is a readily-observable difference between L and R arms, the larger arm is measured.

Values are for a single arm.



PERCENTILES

N=588	min	max	1	5	10	25	50	75	90	95	99
Arm volume (l)	2.57	6.34	2.88	3.18	3.39	3.74	4.11	4.53	4.97	5.21	5.78

22. LEG VOLUME

SUBJECT POSITION: SCANNER

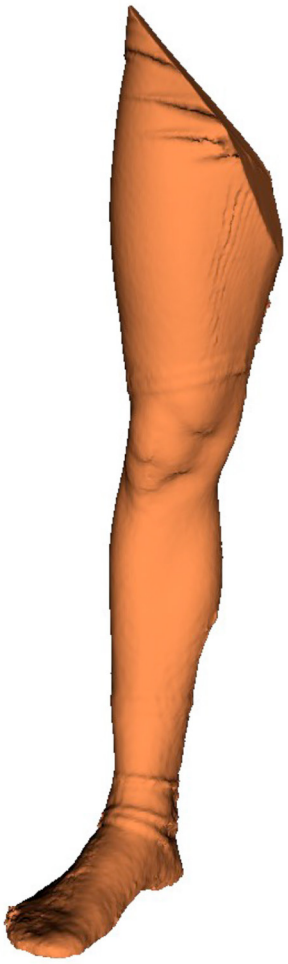
DEFINITION
The volume of one lower limb.

MEASUREMENT
Using the full body scan, identify the leg by placing a cut-line from the hip to the crotch.

NOTES
1. The cut line is an oblique plane at a point approximately mid-way between the greater trochanter and the iliac crest.

2. If there is a readily-observable difference between L and R legs, the larger leg is measured.

Values are for a single leg.



PERCENTILES

N=588	min	max	1	5	10	25	50	75	90	95	99
Leg volume (l)	7.22	23.78	8.86	9.64	10.21	11.25	12.47	13.82	15.07	15.92	18.25

23. TOTAL VOLUME (SURVIVAL SUIT)

SUBJECT POSITION: SCANNER

DEFINITION

The volume of the suited body, including re-breather lifejacket after venting.

PERCENTILES

N=588	min	max	1	5	10	25	50	75	90	95	99
Total volume in Survival Suit (l)	101.96	194.04	112.34	120.91	125.40	131.55	141.07	152.97	161.72	167.59	179.65

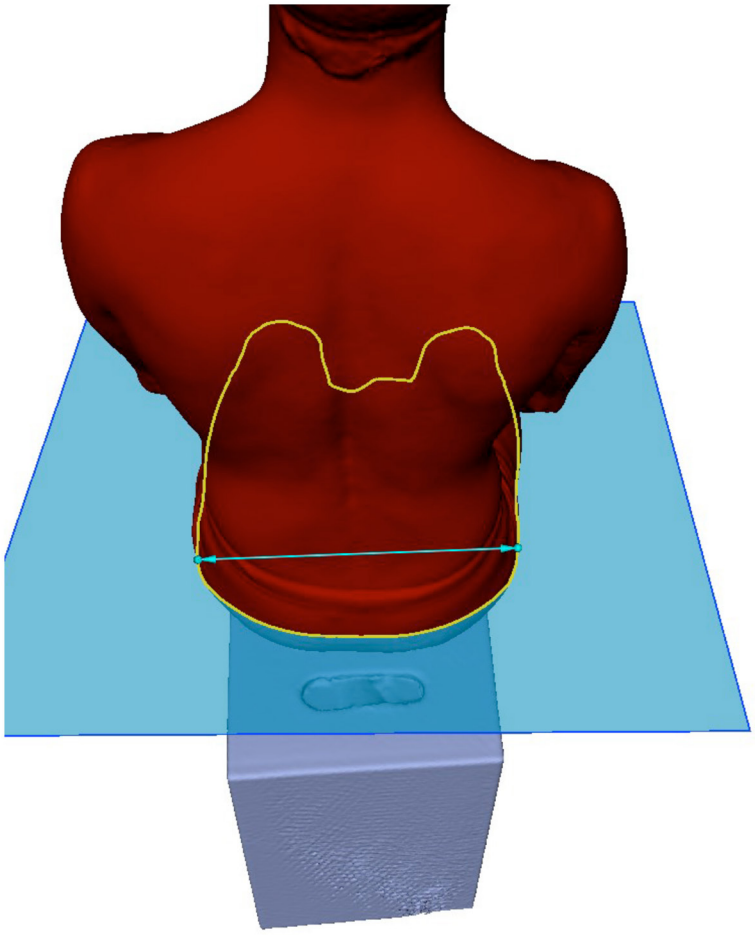
24. HIP BREADTH (SITTING)

SUBJECT POSITION: SEATED

Sitting on a horizontal surface with hands together in the lap.

DEFINITION

The horizontal distance in a transverse plane at the most lateral points of the hip.



PERCENTILES

N=588	min	max	1	5	10	25	50	75	90	95	99
Hip breadth sitting (cm)	30.61	54.89	34.66	35.76	36.40	37.74	39.77	41.61	43.39	44.96	47.38

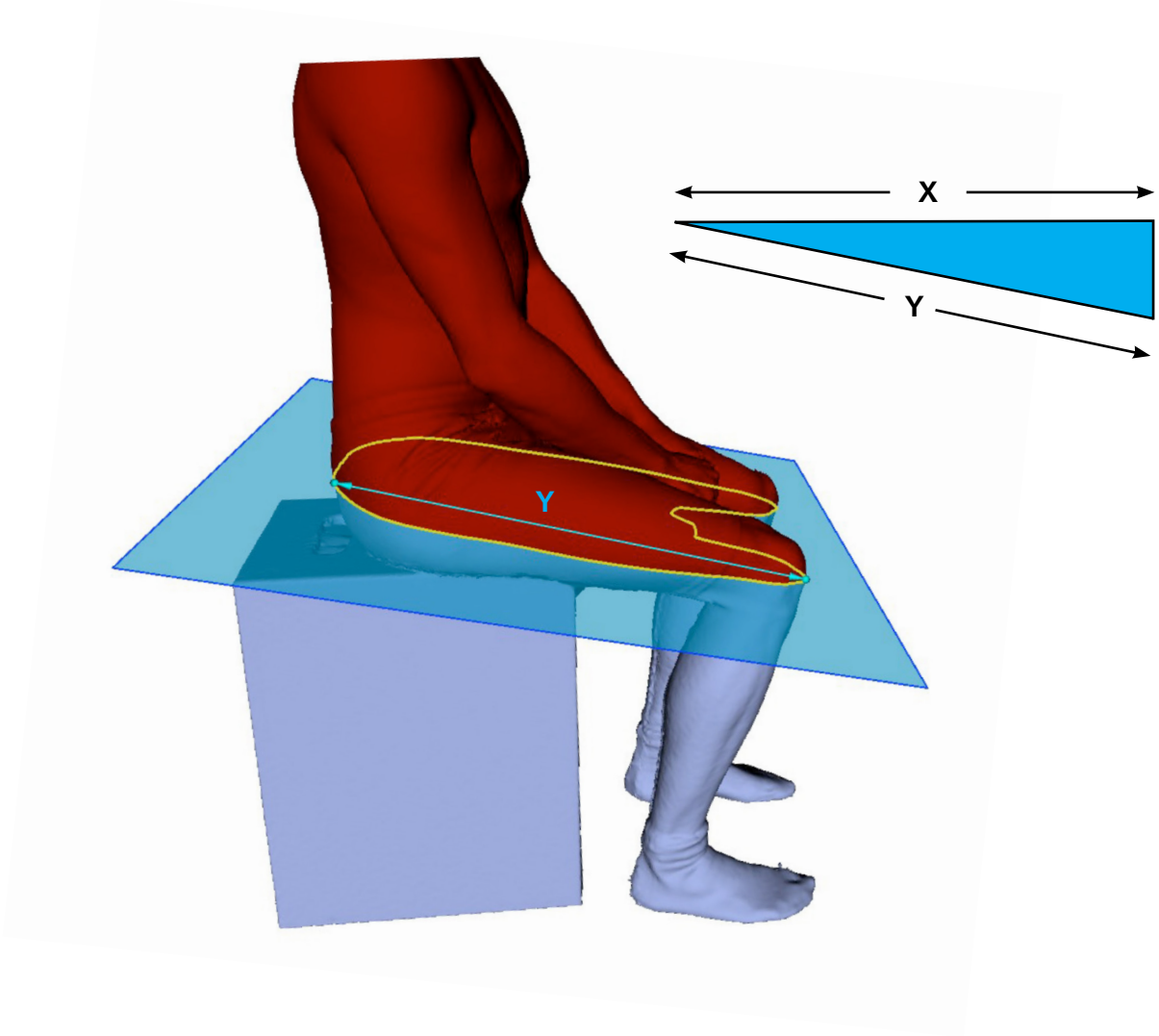
25. BUTTOCK TO ANTERIOR KNEE

SUBJECT POSITION: SEATED

The participant sits on a horizontal surface with hands together in the lap.

DEFINITION

The perpendicular distance (**X**) on a plane between the most posterior aspect of the buttocks to the anterior aspect of the knee.



PERCENTILES

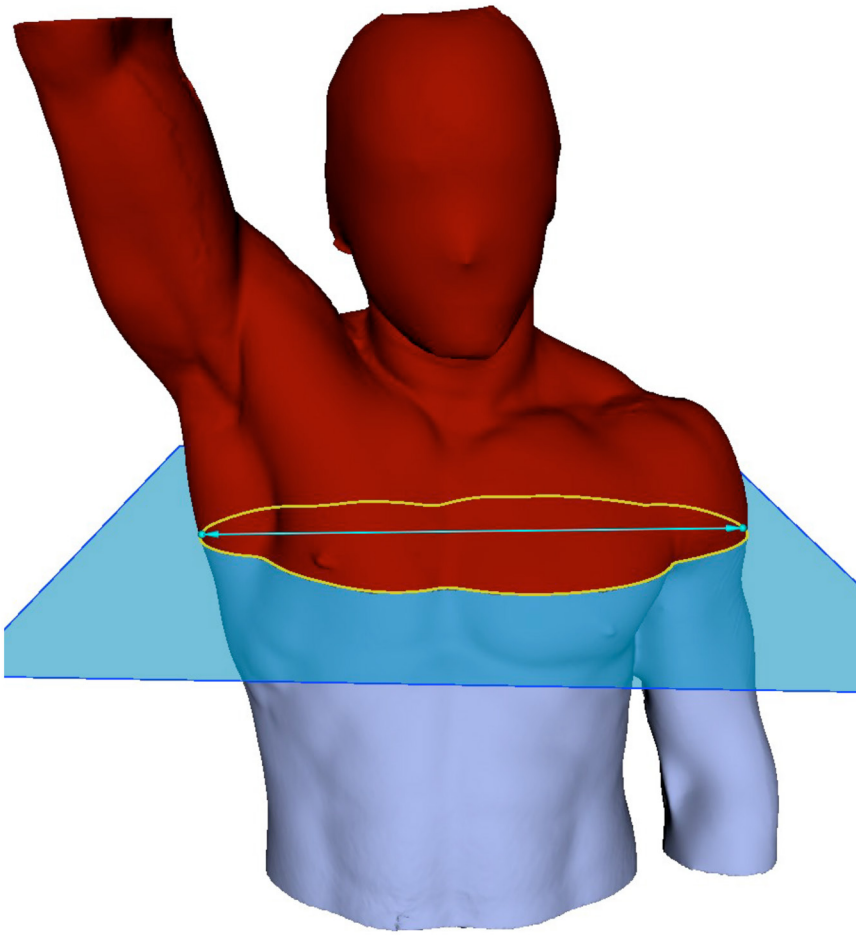
N=588	min	max	1	5	10	25	50	75	90	95	99
Buttock to knee (cm)	54.46	70.66	56.04	58.18	58.84	60.49	62.19	64.16	65.96	67.39	69.33

26. DELTOID TO THORAX

SUBJECT POSITION: RAISED ARM

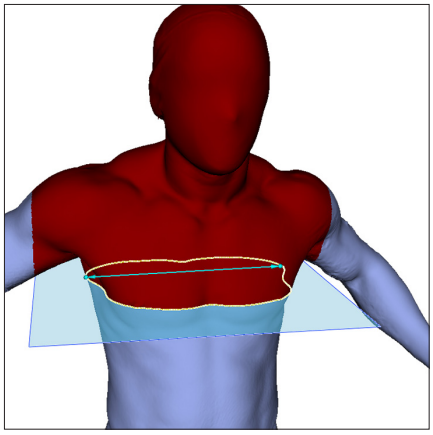
DEFINITION

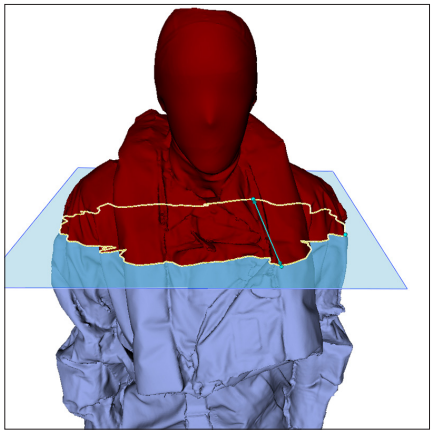
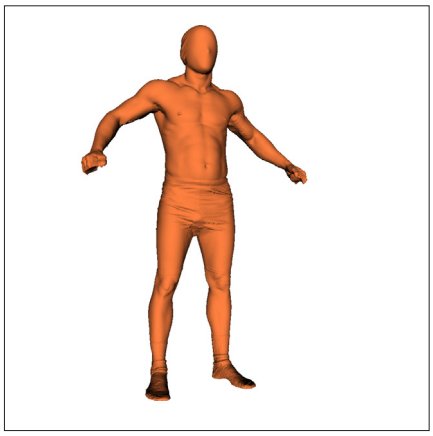
The horizontal distance in a transverse plane between the most lateral points on the deltoid, at the level of the axilla.



PERCENTILES

N=405	min	max	1	5	10	25	50	75	90	95	99
Deltoid to thorax (cm)	37.41	55.40	39.51	41.75	42.39	43.84	45.48	47.02	48.75	50.08	52.26

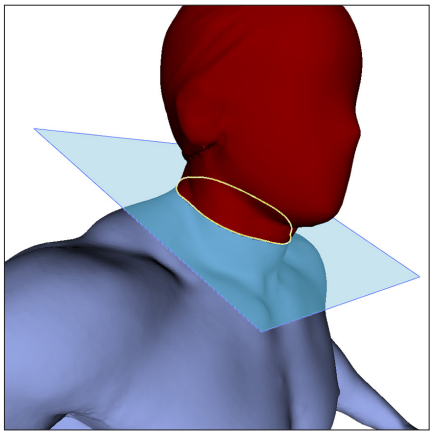


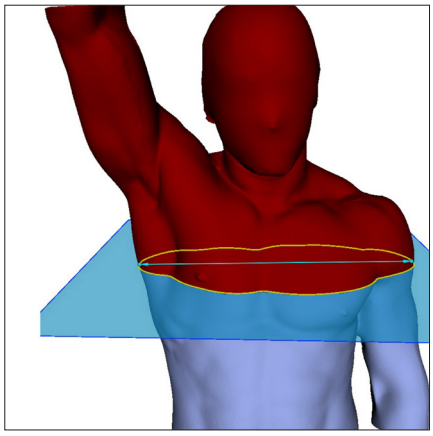



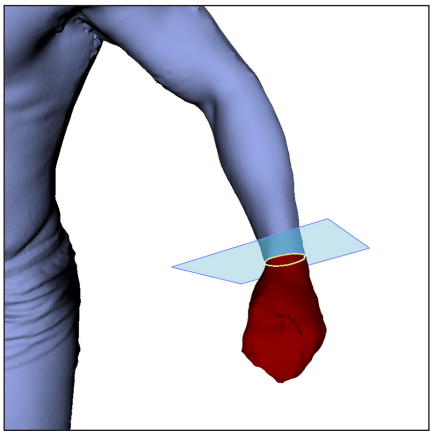
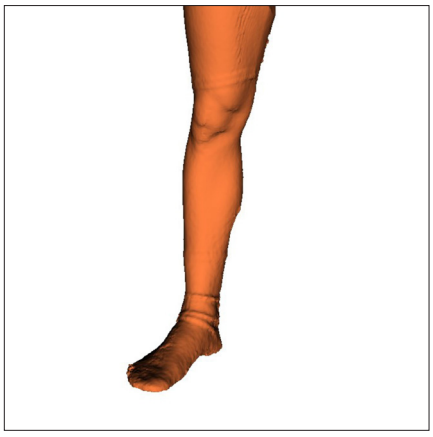
SIZE AND SHAPE OF THE UK OFFSHORE WORKFORCE 2014

Data from the 3D scanning survey

Robert Ledingham, Graham Furnace
Moira Lamb and Arthur Stewart





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