

Supporting Information

Subject-specific body segment parameter estimation using 3D photogrammetry with multiple cameras

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S1. RPi Scanner Data

S1.1 Segment definition

Table S1: Reference points (R1 and R2) for calculating segment lengths and relative CoM. CoM percentage given as distance from the reference point indicated with an * with respect to the segment length.

Segment	R1	R1 Description	R2	R2 Description
Foot	TTIP*	Acropodion – tip of longest toe	HEEL	Pternion - Posterior point on heel
Shank	LMAL	Most lateral point on lateral malleolus	KJC*	Knee joint centre
Thigh	KJC	Knee joint centre	ILIO*	Anterior Illiospinale
Hand	DAC3*	Tip of the 3 rd digit	WJC	Wrist joint centre
Forearm	WJC*	Wrist joint centre	ULNA	Olecranon
Upper Arm	OLEC*	Olecranon	ACR	Acromonion
Head and Neck	CERV	Cervicale (C7)	VERT*	Vertex
Torso	HSP int	Intersection of hip segmentation planes	CERV*	Cervicale (C7)

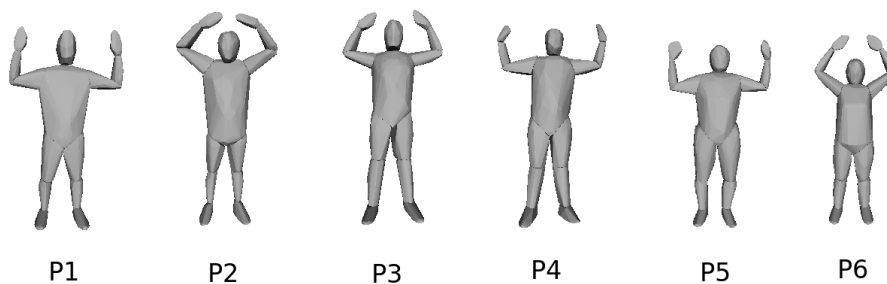


Figure S1: Segmented convex hull of participants P1 – P6.

S1.2. Raw data of mass, centre of mass, segmental lengths, moment and product of inertia

Table S2: Product of inertia I_{xy} in [$10^4 \text{ kg}\cdot\text{m}^2$]. The definition of the coordinate system is shown in Fig. 2. Products of inertia sign convention such that appears as $-I_{xy}$ in the inertia matrix.

Segment	P1 (m)	P2 (m)	P3 (m)	P4 (m)	P5 (f)	P6 (f)
Head	0.44	-16.18	4.48	4.51	-0.77	-1.02
Left Arm	1.06	0.30	-3.15	-0.50	0.55	-0.89
Left Foot	5.01	0.19	0.74	1.74	0.57	0.83
Left Forearm	-0.50	0.07	-0.70	-0.03	0.07	-0.25
Left Hand	0.07	0.40	-0.21	0.25	0.12	-0.19
Left Shank	1.87	0.33	-6.21	1.28	2.04	-1.09
Left Thigh	-0.68	7.44	72.67	20.67	26.92	15.13
Right Arm	0.32	4.35	2.87	-0.10	1.21	0.46
Right Foot	2.15	-1.13	-3.16	-4.59	-3.13	0.07
Right Forearm	0.46	1.55	1.57	0.46	0.08	0.20
Right Hand	-0.11	-0.23	0.12	0.03	0.03	-0.03
Right Shank	-2.51	-0.10	3.19	2.18	-1.35	-0.82
Right Thigh	4.69	-5.47	-22.53	-2.97	-25.84	-29.24
Torso	-115.22	6.49	65.63	-172.87	49.38	17.58

Table S3: Product of inertia I_{xz} in [$10^4 \text{ kg}\cdot\text{m}^2$]. The definition of the coordinate system is shown in Fig. 2. Products of inertia sign convention such that appears as $-I_{xz}$ in the inertia matrix.

Segment	P1 (m)	P2 (m)	P3 (m)	P4 (m)	P5 (f)	P6 (f)
Head	-8.29	-3.35	14.07	-8.55	-8.08	-2.50
Left Arm	-5.49	-0.26	1.28	0.29	-1.86	0.66
Left Foot	-8.23	-7.19	-16.07	-6.79	-4.27	-5.02
Left Forearm	-0.94	-3.17	-0.01	-1.54	0.27	0.16
Left Hand	-0.52	-0.21	0.71	1.65	-0.10	0.30
Left Shank	15.64	11.88	67.74	12.78	19.29	12.45
Left Thigh	171.40	135.82	191.32	43.03	117.98	46.87
Right Arm	-6.20	-7.77	2.90	5.06	-1.63	-1.69
Right Foot	-5.80	-7.00	-6.97	-14.57	-4.49	-3.21
Right Forearm	-0.87	1.69	0.68	-0.51	0.19	-0.32
Right Hand	-0.01	-0.29	-0.08	-0.11	0.09	-0.04
Right Shank	23.49	3.46	56.14	48.99	26.51	9.22
Right Thigh	135.02	122.60	125.98	17.71	98.54	36.01
Torso	-922.65	-1704.73	-1748.64	-594.59	-182.68	-181.54

Table S4: Product of inertia I_{yz} in [$10^4 \text{ kg}\cdot\text{m}^2$]. The definition of the coordinate system is shown in Fig. 2. Products of inertia sign convention such that appears as $-I_{yz}$ in the inertia matrix.

Segment	P1 (m)	P2 (m)	P3 (m)	P4 (m)	P5 (f)	P6 (f)
Head	-1.95	-2.89	2.81	-0.26	-1.87	0.29
Left Arm	9.84	4.63	8.06	10.16	2.83	-1.47
Left Foot	-1.48	-1.50	-1.55	0.64	-0.16	-0.15
Left Forearm	-0.90	-4.27	-1.53	-1.07	-0.05	0.23
Left Hand	-0.12	-0.84	-1.46	1.29	-0.14	-0.19
Left Shank	9.51	8.06	-33.62	-8.71	37.34	7.17
Left Thigh	36.87	108.15	119.51	228.09	134.48	90.97
Right Arm	-16.86	-4.13	-5.31	-12.95	-6.98	-0.47
Right Foot	0.58	2.19	0.87	0.91	0.71	0.64
Right Forearm	1.67	4.19	-0.11	-0.34	0.06	0.22
Right Hand	0.05	0.48	0.41	-0.16	0.06	0.43
Right Shank	-13.30	-0.51	23.84	29.74	-42.05	-0.73
Right Thigh	4.20	-61.89	-79.62	-163.43	-176.06	-80.46
Torso	138.21	-145.92	337.07	932.41	170.31	-7.79

Table S5: Moment of inertia I_{xx} [$1e4 * \text{kg}\cdot\text{m}^2$]. The definition of the coordinate system is shown in Fig. 2.

Segment	P1 (m)	P2 (m)	P3 (m)	P4 (m)	P5 (f)	P6 (f)	Z (m)	Z (f)
Foot	13.4	18.8	17.4	21.0	9.6	9.8	10.3	8.9
Shank	253.4	338.5	871.7	682.3	348.5	261.9	385.0	409.9
Thigh	1491.8	1015.0	1355.9	1576.9	1747.5	831.2	1997.8	1690.1
Hand	7.6	11.8	16.8	10.9	5.2	4.1	13.2	6.0
Forearm	32.8	55.3	46.3	25.5	20.3	19.0	64.2	40.9
UpperArm	122.4	171.3	181.0	174.3	66.9	85.3	127.3	92.3
HeadAndNeck	243.9	314.6	252.0	229.3	136.0	134.2	272.1	183.6
Torso	16077.6	19640.7	18892.9	21624.9	9094.1	8647.9	12421.1	9408.8

Table S6: Moment of inertia I_{yy} [$1e4 * kg*m^2$]. The definition of the coordinate system is shown in Fig. 2.

Segment	P1 (m)	P2 (m)	P3 (m)	P4 (m)	P5 (f)	P6 (f)	Z (m)	Z (f)
Foot	52.0	55.0	67.1	68.1	29.0	28.8	44.0	41.1
Shank	256.4	340.5	889.9	700.1	345.2	264.7	371.0	399.7
Thigh	1564.0	1064.0	1458.5	1660.7	1826.4	871.9	1999.4	1647.3
Hand	6.3	10.6	14.4	9.1	4.1	3.3	8.8	4.4
Forearm	32.3	54.8	46.2	24.8	19.9	18.8	60.2	39.7
UpperArm	112.5	165.9	182.6	164.4	62.8	82.5	114.4	80.7
HeadAndNeck	296.2	365.2	295.4	277.0	161.4	157.0	293.9	216.5
Torso	13828.8	18063.9	18010.0	20063.0	8131.7	8114.4	10807.7	8483.9

Table S7: Moment of inertia I_{zz} [$1e4 * kg*m^2$]. The definition of the coordinate system is shown in Fig. 2.

Segment	P1 (m)	P2 (m)	P3 (m)	P4 (m)	P5 (f)	P6 (f)	Z (m)	Z (f)
Foot	53.3	56.7	69.0	67.3	28.4	29.8	40.0	35.6
Shank	48.2	42.3	143.5	138.1	72.4	57.4	64.6	48.6
Thigh	458.2	285.2	557.0	617.2	590.0	320.3	413.4	324.2
Hand	2.0	3.0	4.9	3.5	1.8	1.1	5.4	2.4
Forearm	5.5	9.7	9.0	5.2	3.1	2.5	12.6	5.3
UpperArm	40.4	44.6	54.9	55.2	23.3	17.5	39.0	26.2
HeadAndNeck	180.0	243.1	184.0	184.0	121.5	109.1	202.4	172.7
Torso	5652.2	6459.0	7523.1	7277.0	3749.9	3203.9	3274.5	2158.7

Table S8: Segment lengths [m] (average between left and right). The definition of the segments and reference points is given in Table A1 - Exceptions: * Foot of P1 and P2: Heel and toe end point of participant's shoes instead of foot. ** Forearm and Upper Arm of Z: Elbow reference point is the elbow joint centre instead of the Olecranon.

Segment	P1 (m)	P2 (m)	P3 (m)	P4 (m)	P5 (f)	P6 (f)
Foot	0.311	0.299	0.319	0.307	0.260	0.261
Shank	0.358	0.405	0.463	0.414	0.375	0.342
Thigh	0.512	0.506	0.467	0.501	0.530	0.433
Hand	0.197	0.209	0.221	0.198	0.165	0.165
Forearm	0.275	0.296	0.284	0.249	0.261	0.247
UpperArm	0.329	0.338	0.330	0.346	0.282	0.321
HeadAndNeck	0.263	0.279	0.255	0.259	0.219	0.226
Torso	0.732	0.800	0.741	0.802	0.649	0.656

Table S9: Segment mass (as % of body weight). P1 - P6: Participants. Z(m): Male average values reported by Zatsiorsky. Z(f): Female average values reported by Zatsiorsky (Leva, 1996; Zatsiorsky, 2002). D(m): Male average values by Dempster (via Zatsiorsky) (Dempster, 1955; Zatsiorsky, 2002).

Segment	P1 (m)	P2 (m)	P3 (m)	P4 (m)	P5 (f)	P6 (f)	Z (m)	Z (f)	D (m)
Foot	1.95	2.17	1.86	2.00	1.68	2.00	1.37	1.29	1.44
Shank	3.64	3.58	5.93	5.52	4.96	5.18	4.33	4.81	4.63
Thigh	12.38	8.94	10.64	11.37	15.93	12.37	14.17	14.78	9.93
Hand	0.44	0.59	0.64	0.48	0.43	0.39	0.61	0.56	0.62
Forearm	1.01	1.34	1.07	0.75	0.81	0.87	1.63	1.38	1.59
Upper Arm	2.72	3.05	2.87	2.75	2.20	2.50	2.7	2.55	2.73
Head and Neck	5.97	6.75	4.95	4.80	4.99	5.60	6.94	6.68	8.13
Torso	49.76	53.90	49.03	49.45	42.97	47.77	43.47	42.57	50.00

Table S10: Centre of mass along the longitudinal axis. P1 - P6: Participants. Z(m: male, f: female): Average values by Zatsiorsky, adjusted by de Leva . The CoM is given as % of the segment length. The definition of the segments and reference points are given in Table S1 - Exceptions: * Foot of participants: Heel and toe end point of participant's shoes instead of foot. ** Forearm and Upper Arm of Z: Elbow reference point is the elbow joint centre instead of the Olecranon (Leva, 1996; Zatsiorsky, 2002).

Segment	P1 (m)	P2 (m)	P3 (m)	P4 (m)	P5 (f)	P6 (f)	Z (m)	Z (f)
Foot	61.1	56.4	57.7	56.9	57.8	59.2	55.9	59.9
Shank	44.9	47.6	45.8	46.1	44.8	47.0	40.5	40.3
Thigh	48.4	50.6	51.8	52.3	50.3	51.3	45.5	46.1
Hand	40.5	58.5	57.1	54.2	53.0	41.2	63.1	65.0
Forearm	47.7	51.7	52.7	53.3	54.4	44.8	57.3	57.4
Upper Arm	42.0	59.3	61.2	58.4	56.8	41.5	55.0	56.0
Head and Neck	50.0	49.1	52.7	50.7	51.9	53.7	50.0	48.4
Torso	49.3	46.5	47.1	47.7	47.6	50.3	43.7	44.2

Table S11: CoM shift in x-direction from the anatomical longitudinal axis in the transverse (x-y) plane. The CoM is given as % of the segment length. The data of the foot is not included due to the participants wearing shoes.

Segment	P1	P2	P3	P4	P5	P6
Head	-0.13	2.71	-1.24	1.07	0.79	1.78
Left Arm	0.27	-0.23	-0.40	-0.35	0.54	-0.43
Left Forearm	0.78	0.39	-0.08	0.22	-0.17	-0.18
Left Hand	0.83	0.64	-0.27	-0.20	0.17	-0.20
Left Shank	-1.08	0.13	0.80	-0.73	-1.59	-1.18
Left Thigh	-1.19	-1.66	-2.64	-0.29	-0.40	0.19
Right Arm	0.52	0.58	-0.58	-0.34	-1.38	-0.26
Right Forearm	0.37	0.07	-0.05	-0.02	0.29	0.33
Right Hand	0.19	0.64	0.42	0.03	0.14	0.13
Right Shank	-2.64	0.21	-2.76	-2.79	-1.72	-1.85
Right Thigh	-0.66	-1.29	0.05	0.61	-0.49	0.01
Torso	0.35	1.50	1.81	1.14	1.24	2.59

Table S12: CoM shift in y-direction from the anatomical longitudinal axis in the transverse (x-y) plane. The CoM is given as % of the segment length. The data of the foot is not included due to the participants wearing shoes.

Segment	P1	P2	P3	P4	P5	P6
Head	-0.16	-0.39	-0.17	-0.34	-0.30	-0.13
Left Arm	-0.56	-0.13	-0.43	-0.89	0.00	0.11
Left Forearm	-0.74	0.43	-0.93	-0.52	-0.43	-0.62
Left Hand	1.05	0.37	0.75	0.04	0.38	-0.05
Left Shank	-0.01	1.04	1.15	0.43	-0.10	1.14
Left Thigh	1.00	0.79	0.46	0.59	1.08	0.30
Right Arm	-0.02	-0.26	0.18	0.16	1.40	0.40
Right Forearm	0.28	0.02	0.34	0.78	0.62	0.43
Right Hand	-0.33	-0.66	-0.22	0.26	-0.05	-1.22
Right Shank	-0.05	-0.34	-0.73	-1.06	0.77	-0.74
Right Thigh	-0.56	-0.85	-0.26	0.00	-1.27	0.28
Torso	-1.16	0.39	-0.62	-1.63	-0.33	-0.11

Table S13: Segment lengths as % of body height (average between left and right). The definition of the segments and reference points is given in Table A1 - Exceptions: * Foot: Heel and toe end point of participant's shoes instead of foot.

Segment	P1 (m)	P2 (m)	P3 (m)	P4 (m)	P5 (f)	P6 (f)
Foot	17.192	16.377	17.208	16.795	15.783	16.478
Shank	19.822	22.178	25.032	22.708	22.784	21.637
Thigh	28.328	27.707	25.232	27.444	32.235	27.369
Hand	10.884	11.451	11.942	10.840	10.043	10.446
Forearm	15.234	16.217	15.357	13.627	15.836	15.630
Upper Arm	18.186	18.513	17.827	18.971	17.164	20.276
Head and Neck	14.541	15.273	13.801	14.212	13.302	14.289
Torso	40.475	43.821	40.013	43.951	39.457	41.479

S2. Visible Human Data

Table S14: Volume of body segments in [$1e3 \cdot m^3$]. S: Original surface mesh. CH: Convex hull of body segment. CHD: Convex hull of divided body segments (only segments indicated with an * were subdivided).

Segment	S	CH	CHD
Head	5.72	6.06	N/A
Left Arm	3.20	3.39	N/A
Left Foot*	1.03	1.29	1.16
Left Forearm*	1.57	1.88	1.67
Left Hand*	0.48	0.70	0.60
Left Shank*	4.27	5.62	4.77
Left Thigh	13.57	14.48	N/A
Right Arm	3.45	3.79	N/A
Right Foot*	1.03	1.30	1.13
Right Forearm*	1.47	1.65	1.53
Right Hand*	0.51	0.75	0.63
Right Shank*	3.98	5.21	4.42
Right Thigh	13.66	14.54	N/A
Torso	50.05	53.63	N/A
Total Body	103.99	114.27	111.78

Table S15: Segment mass (as % of body mass) of the original surface scan, convex hull, regression model and average values. S: Original detailed surface mesh. CH: Convex Hull of whole body segments. CHD: Convex Hull with subdivided body segments (only segments indicated with an * were subdivided as shown in main manuscript in Fig. 10). ZR: Values predicted using Zatsiorsky's linear regression model (using weight and height). Z: Male average values reported by Zatsiorsky. D: Male average values reported by Dempster .

Segment	S	CH	CHD	ZR (m)	Z (m)	D (m)
Foot*	1.02	1.17	1.05	1.30	1.37	1.43
Shank*	4.09	4.88	4.23	4.26	4.33	4.62
Thigh	13.48	13.06	13.36	14.40	14.17	10.00
Hand*	0.49	0.65	0.57	0.58	0.61	0.61
Forearm*	1.51	1.59	1.47	1.57	1.63	1.53
Upper Arm	3.29	3.23	3.30	2.75	2.70	2.64
Head and Neck	5.67	5.45	5.58	5.99	6.94	7.92
Torso	46.58	45.39	46.44	44.29	43.47	51.29

Table S16: Shift of the centre of mass (CoM) between original scan and hulled segments in [mm]. CH_x, CH_y, CH_z: Shift of CoM of the convex hulled segments with respect to the original scan. CHD_x, CHD_y, CHD_z: Shift of th CoM of the dived body segments (only segments indicated with an * were subdivided). Highlighted are values with a shift of larger than 5mm.

Segment	CH_x	CH_y	CH_z	CHD_x	CHD_y	CHD_z
Head	0.40	1.32	4.32	N/A	N/A	N/A
Left Arm	0.21	-1.84	2.39	N/A	N/A	N/A
Left Foot*	0.55	6.29	2.04	-0.42	2.50	0.65
Left Forearm*	5.52	5.15	2.52	0.18	0.19	0.24
Left Hand*	10.40	-1.43	9.15	5.63	0.15	6.91
Left Shank*	-0.26	7.80	14.81	0.04	2.55	4.17
Left Thigh	0.66	-2.52	3.68	N/A	N/A	N/A
Right Arm	-0.72	-0.14	4.76	N/A	N/A	N/A
Right Foot*	-1.65	5.34	2.12	0.05	1.99	0.84
Right Forearm*	-3.74	3.55	1.31	-0.11	0.10	0.10
Right Hand*	-10.55	-4.01	4.85	-5.35	-0.92	3.73
Right Shank*	-1.59	6.88	13.23	-0.66	2.57	3.10
Right Thigh	-0.44	-2.41	4.10	N/A	N/A	N/A
Torso	1.94	-1.97	1.65	N/A	N/A	N/A

Table S17: Inertial tensor values Visible Human high-resolution mesh (see Fig.8A in main manuscript) in [$10^4 \text{ kg}\cdot\text{m}^2$]. Products of inertia sign convention such that they appear as -Ixy, -Ixz and -Iyz in the inertia matrix. Note: The visible human body segments were not rotated into the standard anatomical position, thus Ixx, Iyy and Izz do not correspond to principal body axes (see coordinate system in main manuscript Fig. 8).

Body Segment:	Ixx	Iyy	Izz	Ixy	Ixz	Iyz
Head	329.7	283.4	197.3	-0.6	9.3	1.7
Left Arm	224.4	204.4	58.9	3.1	-21.2	-15.8
Left Foot	33.6	14.3	27.2	-1.0	-0.7	10.5
Left Forearm	72.3	53.8	39.9	9.5	12.4	26.8
Left Hand	5.9	8.2	5.2	1.2	1.7	0.7
Left Shank	479.6	479.6	80.4	-1.6	-46.3	-18.8
Left Thigh	2226.3	2138.9	611.2	-13.4	158.0	53.4
Right Arm	283.2	260.4	61.6	-3.1	18.9	-7.5
Right Foot	33.2	16.8	23.7	-0.7	-0.1	11.1
Right Forearm	58.8	46.4	43.9	-14.3	-16.0	22.2
Right Hand	5.4	8.5	6.1	-1.0	-1.5	0.0
Right Shank	444.1	441.0	72.5	-2.1	47.2	-26.2
Right Thigh	2259.8	2155.2	619.2	-4.2	-124.9	62.0
Torso	16660.7	17909.0	5617.5	-53.4	-215.1	400.5

Table S18: Inertial tensor values Visible Human convex hull mesh (see Fig.8B in main manuscript) in [$10^4 \text{ kg}\cdot\text{m}^2$]. Products of inertia sign convention such that they appear as -Ixy, -Ixz and -Iyz in the inertia matrix. Note: The visible human body segments were not rotated into the standard anatomical position, thus Ixx, Iyy and Izz do not correspond to principal body axes (see coordinate system in main manuscript Fig. 8).

Body Segment:	Ixx	Iyy	Izz	Ixy	Ixz	Iyz
Head	326.0	277.2	200.1	-1.4	9.1	3.3
Left Arm	219.1	196.9	60.0	2.0	-19.2	-17.0
Left Foot	39.2	16.6	32.9	-1.4	-0.8	11.4
Left Forearm	78.4	60.0	46.4	11.8	14.1	28.6
Left Hand	8.1	12.0	7.5	1.3	3.0	0.6
Left Shank	613.1	600.6	112.6	-3.2	-55.1	-19.3
Left Thigh	2193.3	2098.2	625.2	-16.8	156.1	28.2
Right Arm	286.9	257.6	68.0	-2.6	16.2	-6.5
Right Foot	38.5	19.3	28.9	-0.6	0.0	12.0
Right Forearm	59.3	47.6	46.3	-15.1	-16.1	21.8
Right Hand	7.0	11.8	9.0	-0.6	-2.2	-0.4
Right Shank	556.0	540.8	100.1	-3.3	53.6	-29.9
Right Thigh	2214.7	2106.1	628.6	-3.0	-121.3	40.2
Torso	16146.1	17431.3	5828.5	-45.2	-178.5	282.4

Table S19: Inertial tensor values Visible Human convex hull mesh of divided segments (see Fig.10 in main manuscript, only segments indicated with an * were subdivided) in [10^4 kg*m²]. Products of inertia sign convention such that they appear as -I_{xy}, -I_{xz} and -I_{yz} in the inertia matrix. Note: The visible human body segments were not rotated into the standard anatomical position, thus I_{xx}, I_{yy} and I_{zz} do not correspond to principal body axes (see coordinate system in main manuscript Fig. 8).

Body Segment:	I _{xx}	I _{yy}	I _{zz}	I _{xy}	I _{xz}	I _{yz}
Head	333.3	283.4	204.5	1.5	-9.3	-3.4
Left Arm	224.0	201.3	61.4	-2.0	19.6	17.4
Left Foot*	36.0	15.3	29.2	0.9	0.7	-2.8
Left Forearm*	74.4	56.2	41.6	-10.5	-13.6	-27.8
Left Hand*	7.5	10.6	6.3	-1.3	-2.6	-0.8
Left Shank*	529.8	528.0	89.8	1.3	52.0	22.9
Left Thigh	2242.2	2145.0	639.1	17.2	-159.6	-28.9
Right Arm	293.3	263.3	69.5	2.6	-16.6	6.6
Right Foot*	34.6	17.5	25.0	0.6	0.0	-11.6
Right Forearm*	57.8	45.9	43.5	14.3	15.8	-21.8
Right Hand*	6.3	10.2	7.3	0.8	2.0	0.1
Right Shank*	486.9	481.2	80.6	2.7	-51.8	31.4
Right Thigh	2264.1	2153.1	642.6	3.1	3.1	-41.1
Torso	16506.3	17820.2	5958.6	46.2	182.5	-288.7

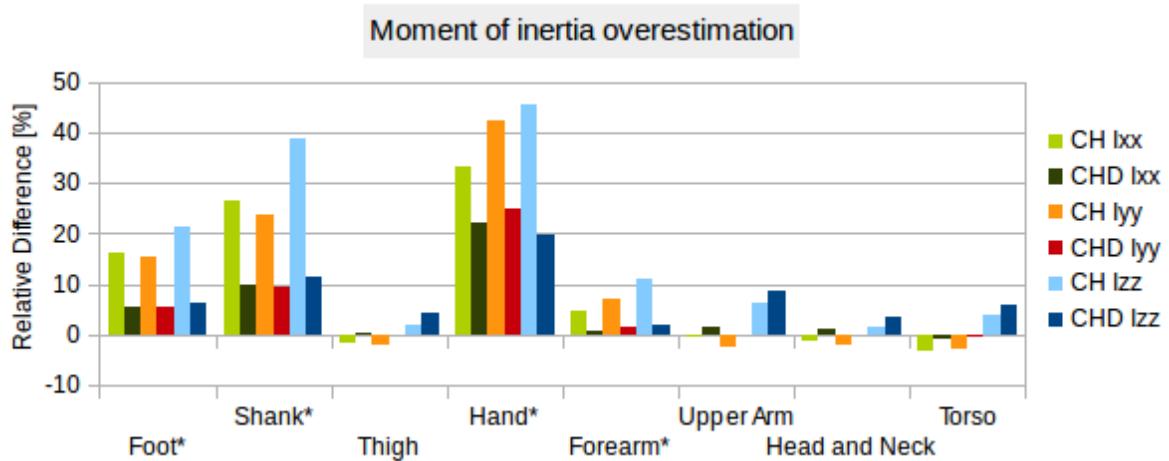


Figure S2: Moment of inertia overestimation of the hulled versus original mehs of the visible human data set CH: Convex hull, CHD: Divided Convex Hull. Note: The visible human body segments were not rotated into the standard anatomical position, thus I_{xx}, I_{yy} and I_{zz} do not correspond to principal body axes (see coordinate system in main manuscript Fig. 8).

S3. Inertial parameters from a surface mesh

Matlab script to calculate inertial parameters of a volume described by a surface mesh.

Pseudo code derived by David Eberly, reported in “Polyhedral Mass Properties (Revisited)”, available at: <http://geometrictools.com/Documentation/PolyhedralMassProperties.pdf>.

Translated into Matlab code by Kathrin E. Peyer.

```
function [mass,cm,inertia] = ComputeBodyProperties(p,index)

mult = [1/6,1/24,1/24,1/24,1/60,1/60,1/60,1/120,1/120,1/120];

intg = [0,0,0,0,0,0,0,0,0,0]; % order: 1, x, y, z, x^2, y^2, z^2, xy, yz,
zx

for t = 1:length(index)

    % get vertices of triangle t
    i0 = index(t,1);
    i1 = index(t,2);
    i2 = index(t,3);

    x0 = p(i0,1);
    y0 = p(i0,2);
    z0 = p(i0,3);

    x1 = p(i1,1);
    y1 = p(i1,2);
    z1 = p(i1,3);

    x2 = p(i2,1);
    y2 = p(i2,2);
    z2 = p(i2,3);

    % get edges and cross product of edges
    a1 = x1-x0;
    b1 = y1-y0;
    c1 = z1-z0;
    a2 = x2-x0;
    b2 = y2-y0;
    c2 = z2-z0;
    d0 = b1*c2-b2*c1;
    d1 = a2*c1-a1*c2;
    d2 = a1*b2-a2*b1;

    % compute integral terms
    [f1x,f2x,f3x,g0x,g1x,g2x] = Subexpressions(x0,x1,x2);
    [f1y,f2y,f3y,g0y,g1y,g2y] = Subexpressions(y0,y1,y2);
    [f1z,f2z,f3z,g0z,g1z,g2z] = Subexpressions(z0,z1,z2);
```

```

    % update integrals
    intg(1) = intg(1) + d0*f1x;
    intg(2) = intg(2) + d0*f2x;
    intg(3) = intg(3) + d1*f2y;
    intg(4) = intg(4) + d2*f2z;
    intg(5) = intg(5) + d0*f3x;
    intg(6) = intg(6) + d1*f3y;
    intg(7) = intg(7) + d2*f3z;
    intg(8) = intg(8) + d0*(y0*g0x+y1*g1x+y2*g2x);
    intg(9) = intg(9) + d1*(z0*g0y+z1*g1y+z2*g2y);
    intg(10) = intg(10) + d2*(x0*g0z+x1*g1z+x2*g2z);
end

intg = intg.*mult;

mass = intg(1);

%% Center of mass:
% CoM.x = cm(1)
% CoM.y = cm(2)
% CoM.z = cm(3)

cm(1) = intg(2)/mass;
cm(2) = intg(3)/mass;
cm(3) = intg(4)/mass;

%% Inertia: given wrt center of mass
% I11 = inertia(1)
% I22 = inertia(2)
% I33 = inertia(3)
% I12 = inertia(4)
% I13 = inertia(5)
% I23 = inertia(6)

inertia(1) = intg(6)+intg(7)-mass*(cm(2)*cm(2)+cm(3)*cm(3));
inertia(2) = intg(5)+intg(7)-mass*(cm(3)*cm(3)+cm(1)*cm(1));
inertia(3) = intg(5)+intg(6)-mass*(cm(1)*cm(1)+cm(2)*cm(2));
inertia(4) = -(intg(8)-mass*cm(1)*cm(2));
inertia(5) = -(intg(10)-mass*cm(3)*cm(1));
inertia(6) = -(intg(9)-mass*cm(2)*cm(3));

end

function [f1,f2,f3,g0,g1,g2] = Subexpressions(w0,w1,w2)
    temp0 = w0+w1;
    temp1 = w0*w0;
    temp2 = temp1+w1*temp0;

    f1 = temp0+w2;
    f2 = temp2+w2*f1;
    f3 = w0*temp1+w1*temp2+w2*f2;
    g0 = f2+w0*(f1+w0);
    g1 = f2+w1*(f1+w1);
    g2 = f2+w2*(f1+w2);
end

```