

Figure S1. Changes in the sagittal plane hip joint mechanical work (W_{EX}) during hip extension. Results for young adults are located in the first row. Results for middle-aged adults are located in the second row. Results for walking at different speeds (100, 115, and 130%) are located in the columns. Baseline conditions are highlighted in orange with a unit of J/kg. Other values are relative differences with respect to the baseline value within the same cluster. Comparisons that are statistically significant ($p < 0.05$) are in bold with a green background for a positive (+) change. Within each cluster, added mass conditions with a higher total amount of added mass sit further to the right, and those with a higher center of added mass sit further away from the bottom.

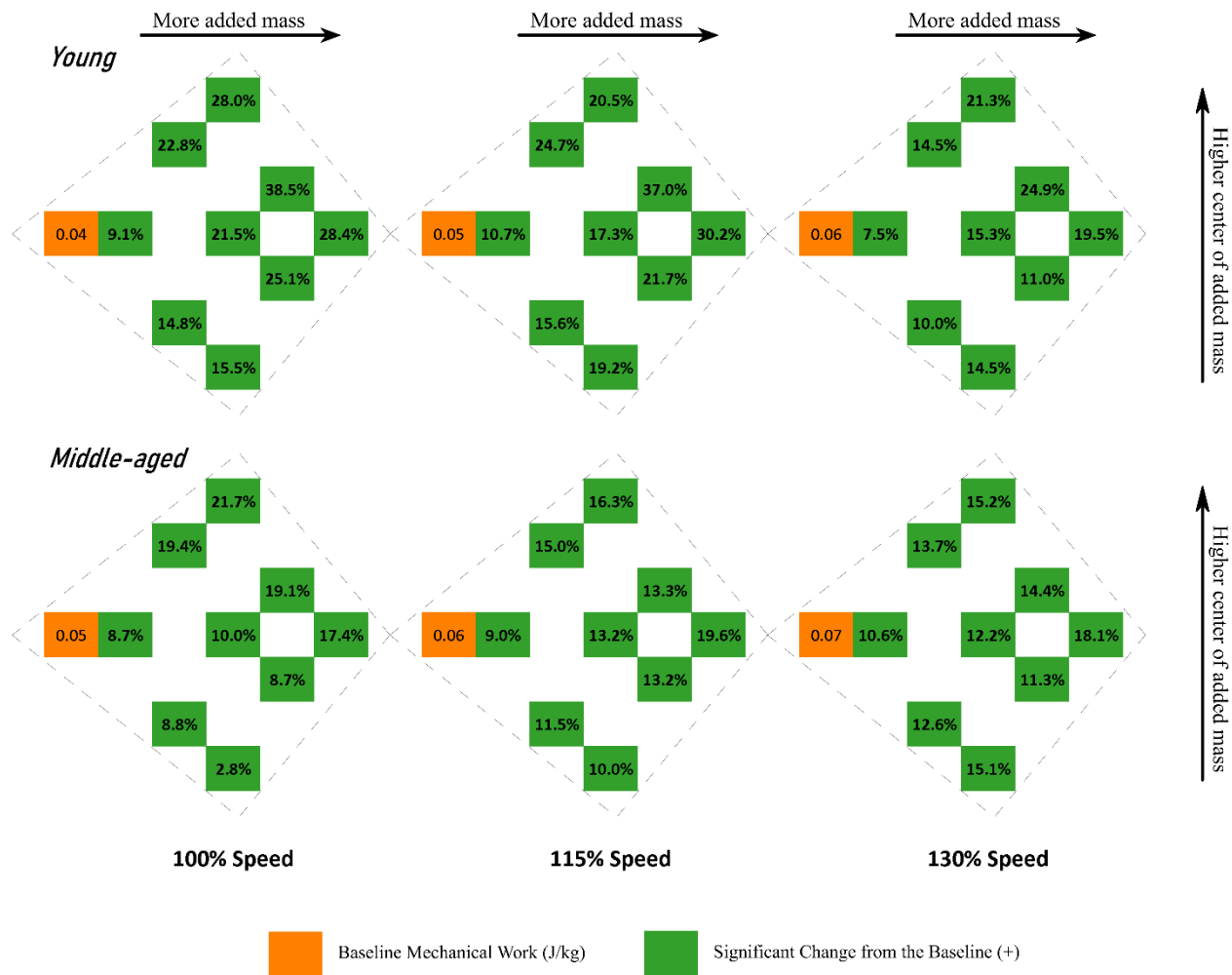


Figure S2. Changes in the sagittal plane hip joint mechanical work (W_{FL}) during hip flexion. Results for young adults are located in the first row. Results for middle-aged adults are located in the second row. Results for walking at different speeds (100, 115, and 130%) are located in the columns. Baseline conditions are highlighted in orange with a unit of J/kg. Other values are relative differences with respect to the baseline value within the same cluster. Comparisons that are statistically significant ($p < 0.05$) are in bold with a green background for a positive (+) change. Within each cluster, added mass conditions with a higher total amount of added mass sit further to the right, and those with a higher center of added mass sit further away from the bottom.

Table S1. Pairwise comparisons: Sagittal plane hip joint quasi-stiffness (K_{EX}) during hip extension.

Speed		100%				115%				130%			
Young	Condition	00	11	12	13	00	11	12	13	00	11	12	13
	Mean	2.24	2.30	2.36	2.38	2.49	2.53	2.59	2.63	2.75	2.76	2.82	2.85
	SD	0.46	0.47	0.50	0.50	0.51	0.53	0.52	0.56	0.54	0.58	0.54	0.58
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		0.2603	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
	Condition		21	22	23		21	22	23		21	22	23
	Mean		2.41	2.37	2.41		2.64	2.63	2.62		2.94	2.90	2.91
	SD		0.53	0.50	0.51		0.54	0.50	0.57		0.65	0.58	0.68
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		0.2834	< 0.0001	< 0.0001
	Condition		31	32	33		31	32	33		31	32	33
	Mean		2.44	2.41	2.50		2.66	2.74	2.73		2.97	2.99	2.98
	SD		0.57	0.49	0.51		0.62	0.61	0.56		0.69	0.72	0.66
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
Middle-aged	Condition	00	11	12	13	00	11	12	13	00	11	12	13
	Mean	2.40	2.42	2.29	2.43	2.64	2.64	2.51	2.59	2.83	2.88	2.71	2.81
	SD	0.75	0.71	0.64	0.66	0.78	0.75	0.66	0.59	0.80	0.77	0.67	0.62
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		0.9941	< 0.0001	0.1408		< 0.0001	0.7887	< 0.0001
	Condition		21	22	23		21	22	23		21	22	23
	Mean		2.49	2.50	2.44		2.74	2.70	2.65		2.97	2.90	2.86
	SD		0.67	0.70	0.70		0.70	0.69	0.68		0.72	0.72	0.67
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	0.8930		< 0.0001	< 0.0001	< 0.0001
	Condition		31	32	33		31	32	33		31	32	33
	Mean		2.48	2.47	2.51		2.67	2.71	2.68		2.88	2.88	2.92
	SD		0.67	0.71	0.64		0.68	0.72	0.71		0.70	0.74	0.73
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		0.6567	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001

Mean and SD (Standard deviation) are in Nm/kg/rad. Bold *p*-values < 0.05. Comparisons are with respect to the baseline, “00” condition, within the same speed and age category. Condition names are defined in Table 1.

Table S2. Pairwise comparisons: Sagittal plane hip joint quasi-stiffness (K_{FL}) during hip flexion.

Speed		100%				115%				130%			
Young	Condition	00	11	12	13	00	11	12	13	00	11	12	13
	Mean	2.42	2.20	2.21	2.26	2.82	2.51	2.52	2.65	3.40	2.96	2.95	3.05
	SD	0.66	0.58	0.60	0.63	0.75	0.66	0.63	0.66	0.94	0.74	0.82	0.79
	<i>p</i> -value	-	< 0.0001	< 0.0001	< 0.0001	-	< 0.0001	< 0.0001	< 0.0001	-	< 0.0001	< 0.0001	< 0.0001
	Condition		21	22	23		21	22	23		21	22	23
	Mean		2.16	2.20	2.17		2.55	2.50	2.47		2.93	2.93	3.02
	SD		0.68	0.63	0.62		0.74	0.68	0.75		0.89	0.80	1.07
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
	Condition		31	32	33		31	32	33		31	32	33
	Mean		2.19	2.19	2.25		2.49	2.46	2.48		2.86	2.84	2.88
	SD		0.69	0.62	0.70		0.79	0.60	0.90		0.84	0.82	0.99
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
Middle-aged	Condition	00	11	12	13	00	11	12	13	00	11	12	13
	Mean	2.92	2.86	2.89	2.92	3.30	3.25	3.32	3.35	3.78	3.71	3.71	3.78
	SD	1.11	0.94	0.94	1.02	1.21	1.06	1.05	1.11	1.33	1.21	1.20	1.20
	<i>p</i> -value		0.4786	0.9220	0.9948	-	0.7780	0.9224	0.6401	-	< 0.0001	0.0707	0.9980
	Condition		21	22	23		21	22	23		21	22	23
	Mean		2.86	2.78	2.98		3.19	3.19	3.40		3.66	3.66	3.92
	SD		0.95	0.93	1.08		1.01	1.05	1.18		1.15	1.16	1.34
	<i>p</i> -value		0.5404	< 0.0001	0.5951		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
	Condition		31	32	33		31	32	33		31	32	33
	Mean		2.86	2.83	2.92		3.16	3.28	3.31		3.61	3.67	3.79
	SD		0.97	0.94	0.93		1.00	1.07	1.01		1.14	1.20	1.18
	<i>p</i> -value		< 0.0001	0.0020	0.9981		< 0.0001	0.9407	< 0.0001		< 0.0001	< 0.0001	< 0.0001

Mean and SD (Standard deviation) are in Nm/kg/rad. Bold *p*-values < 0.05. Comparisons are with respect to the baseline, “00” condition, within the same speed and age category. Condition names are defined in Table 1.

Table S3. Pairwise comparisons: Sagittal plane hip joint mechanical work (W_{EX}) during hip extension.

Speed		100%				115%				130%			
Young	Condition	00	11	12	13	00	11	12	13	00	11	12	13
	Mean	-0.06	-0.06	-0.06	-0.06	-0.07	-0.07	-0.07	-0.08	-0.09	-0.09	-0.09	-0.09
	SD	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		0.4534	0.0002	< 0.0001		< 0.0001	< 0.0001	< 0.0001
	Condition		21	22	23		21	22	23		21	22	23
	Mean		-0.07	-0.07	-0.07		-0.09	-0.08	-0.08		-0.10	-0.10	-0.09
	SD		0.04	0.03	0.03		0.05	0.04	0.04		0.05	0.04	0.04
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
	Condition		31	32	33		31	32	33		31	32	33
	Mean		-0.07	-0.07	-0.06		-0.09	-0.09	-0.07		-0.10	-0.09	-0.09
	SD		0.05	0.03	0.03		0.05	0.08	0.04		0.05	0.04	0.04
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
Middle-aged	Condition	00	11	12	13	00	11	12	13	00	11	12	13
	Mean	-0.06	-0.07	-0.08	-0.07	-0.07	-0.08	-0.09	-0.08	-0.08	-0.09	-0.10	-0.10
	SD	0.07	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.07	0.08	0.08	0.08
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
	Condition		21	22	23		21	22	23		21	22	23
	Mean		-0.07	-0.07	-0.07		-0.08	-0.09	-0.09		-0.10	-0.10	-0.10
	SD		0.07	0.07	0.08		0.07	0.08	0.08		0.07	0.08	0.08
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
	Condition		31	32	33		31	32	33		31	32	33
	Mean		-0.08	-0.07	-0.08		-0.09	-0.09	-0.09		-0.10	-0.10	-0.10
	SD		0.08	0.07	0.08		0.07	0.07	0.08		0.07	0.08	0.07
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001

Mean and SD (Standard deviation) are in J/kg. Bold *p*-values < 0.05. Comparisons are with respect to the baseline, “00” condition, within the same speed and age category. Condition names are defined in Table 1.

Table S4. Pairwise comparisons: Sagittal plane hip joint mechanical work (W_{FL}) during hip flexion.

Speed		100%				115%				130%			
Young	Condition	00	11	12	13	00	11	12	13	00	11	12	13
	Mean	0.04	0.04	0.04	0.04	0.05	0.06	0.06	0.06	0.06	0.07	0.07	0.07
	SD	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.03	0.03
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
	Condition		21	22	23		21	22	23		21	22	23
	Mean		0.05	0.05	0.05		0.06	0.06	0.06		0.07	0.07	0.07
	SD		0.02	0.02	0.02		0.02	0.02	0.02		0.03	0.03	0.03
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
	Condition		31	32	33		31	32	33		31	32	33
	Mean		0.05	0.05	0.05		0.06	0.07	0.06		0.08	0.08	0.08
	SD		0.02	0.02	0.02		0.03	0.03	0.03		0.03	0.03	0.03
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
Middle-aged	Condition	00	11	12	13	00	11	12	13	00	11	12	13
	Mean	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.07	0.08	0.08	0.08
	SD	0.03	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04
	<i>p</i> -value		< 0.0001	< 0.0001	0.7479		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
	Condition		21	22	23		21	22	23		21	22	23
	Mean		0.05	0.05	0.05		0.07	0.06	0.06		0.08	0.08	0.08
	SD		0.03	0.03	0.03		0.03	0.03	0.03		0.04	0.03	0.04
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001
	Condition		31	32	33		31	32	33		31	32	33
	Mean		0.06	0.05	0.05		0.07	0.06	0.07		0.08	0.08	0.08
	SD		0.03	0.03	0.03		0.03	0.03	0.03		0.04	0.03	0.04
	<i>p</i> -value		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001		< 0.0001	< 0.0001	< 0.0001

Mean and SD (Standard deviation) are in J/kg. Bold *p*-values < 0.05. Comparisons are with respect to the baseline, “00” condition, within the same speed and age category. Condition names are defined in Table 1.

Table S5. Sagittal plane hip joint quasi-stiffness (K_{EX}) for each participant during hip extension.

Participant	Gender	Age	Age category	Body mass	Body height	# K_{EX}	Mean R^2	Mean RMSE	#Frames	K_{EX} range	Mean W_{EX}
1	M	22	Y	76.35	1.73	3144	0.93	0.074	36	[1.560, 4.620]	-0.101
2	M	23	Y	67.30	1.75	3064	0.96	0.044	32	[1.324, 3.229]	-0.059
3	F	23	Y	68.71	1.78	2224	0.95	0.039	35	[1.077, 6.437]	-0.093
4	M	20	Y	56.71	1.78	2697	0.88	0.122	41	[1.586, 4.095]	-0.074
5	F	53	M	74.84	1.65	3040	0.96	0.044	31	[1.380, 4.230]	-0.072
6	F	23	Y	79.66	1.63	3530	0.93	0.064	29	[1.309, 5.703]	-0.080
7	F	37	M	76.45	1.56	3350	0.90	0.077	43	[1.457, 3.094]	-0.091
8	M	31	Y	68.94	1.83	3120	0.97	0.049	33	[2.540, 4.977]	-0.064
9	F	36	M	68.94	1.63	3368	0.95	0.054	39	[1.528, 4.026]	-0.102
10	M	41	M	76.37	1.82	3340	0.88	0.117	34	[2.884, 5.423]	-0.061
11	F	36	M	85.33	1.71	3121	0.81	0.144	46	[1.164, 3.383]	-0.081
12	F	41	M	71.78	1.70	3144	0.88	0.077	38	[1.402, 2.939]	-0.046
13	M	54	M	102.84	1.83	2413	0.92	0.089	51	[1.415, 2.832]	-0.134
14	M	40	M	89.48	1.71	3270	0.90	0.090	34	[2.388, 5.779]	-0.054
15	F	20	Y	62.22	1.65	2194	0.92	0.058	47	[1.291, 2.877]	-0.034
16	F	18	Y	67.08	1.71	2453	0.96	0.053	36	[1.695, 3.946]	-0.092
17	M	19	Y	73.80	1.80	2614	0.96	0.036	29	[1.899, 4.662]	-0.054
18	M	18	Y	67.81	1.69	3063	0.94	0.069	44	[1.351, 3.227]	-0.135
19	F	22	Y	70.31	1.63	3057	0.97	0.029	27	[1.682, 4.094]	-0.030
20	F	38	M	53.77	1.68	2808	0.93	0.071	41	[1.067, 3.088]	-0.047
21	F	37	M	54.84	1.59	3371	0.90	0.091	31	[1.580, 5.197]	-0.098
22	F	38	M	59.01	1.68	2935	0.95	0.051	34	[1.704, 4.086]	-0.042
23	F	43	M	64.09	1.73	2748	0.92	0.109	46	[1.745, 3.810]	-0.356
24	M	60	M	79.48	1.83	2317	0.96	0.031	25	[1.047, 5.580]	-0.038
25	M	27	Y	64.09	1.80	2908	0.93	0.078	46	[1.332, 3.100]	-0.129
26	F	44	M	56.20	1.57	2520	0.97	0.024	35	[0.873, 3.583]	-0.021
27	M	61	M	92.28	1.82	2995	0.97	0.026	20	[1.603, 6.040]	-0.029
28	M	55	M	79.62	1.71	2945	0.95	0.068	34	[1.893, 5.141]	-0.112
29	M	27	Y	88.67	1.77	3083	0.92	0.064	38	[1.646, 3.827]	-0.065
Mean				72.83	1.71	2820	0.93	0.068	36	2.651	-0.082
SD				12.86	0.08	509	0.05	0.037	8	0.675	0.063

Body mass in kilograms;

Body height in meters;

Age category: Y for young adults, and M for middle-aged adults;

K_{EX} : Number of hip joint quasi-stiffness values during hip extension, both sides included;Mean R^2 : Mean R-squared value of the curve fitting;

Mean RMSE: Mean root mean squared error of the curve fitting (Nm/kg);

#Frames: Average number of frames used for the curve fitting for each K_{EX} value; K_{EX} range: Range of K_{EX} (Nm/kg/rad);Mean W_{EX} : Average mechanical work at the hip joint during hip extension (J/kg);

SD: Standard deviation;

Sampling frequency: 150 Hz.

Table S6. Sagittal plane hip joint quasi-stiffness (K_{FL}) for each participant during hip flexion.

Participant	Gender	Age	Age category	Body mass	Body height	# K_{FL}	Mean R^2	Mean RMSE	#Frames	K_{FL} range	Mean W_{FL}
1	M	22	Y	76.35	1.73	3144	0.89	0.106	16	[1.516, 8.060]	0.050
2	M	23	Y	67.30	1.75	3064	0.91	0.069	19	[0.612, 3.974]	0.054
3	F	23	Y	68.71	1.78	2224	0.88	0.075	25	[0.388, 4.718]	0.066
4	M	20	Y	56.71	1.78	2697	0.80	0.133	21	[0.950, 4.334]	0.091
5	F	53	M	74.84	1.65	3040	0.93	0.071	18	[1.009, 5.211]	0.064
6	F	23	Y	79.66	1.63	3530	0.91	0.071	17	[1.251, 6.082]	0.076
7	F	37	M	76.45	1.56	3350	0.94	0.074	17	[1.829, 4.371]	0.058
8	M	31	Y	68.94	1.83	3120	0.86	0.094	22	[0.654, 4.098]	0.081
9	F	36	M	68.94	1.63	3368	0.94	0.079	18	[2.092, 6.288]	0.072
10	M	41	M	76.37	1.82	3340	0.93	0.101	20	[3.291, 7.604]	0.064
11	F	36	M	85.33	1.71	3121	0.96	0.070	20	[1.627, 4.172]	0.104
12	F	41	M	71.78	1.70	3144	0.96	0.053	18	[2.069, 6.303]	0.040
13	M	54	M	102.84	1.83	2413	0.83	0.137	19	[1.675, 6.910]	0.050
14	M	40	M	89.48	1.71	3270	0.86	0.094	17	[1.583, 8.252]	0.046
15	F	20	Y	62.22	1.65	2194	0.89	0.066	23	[1.026, 2.731]	0.045
16	F	18	Y	67.08	1.71	2453	0.95	0.062	21	[1.534, 3.921]	0.100
17	M	19	Y	73.80	1.80	2614	0.94	0.060	20	[1.532, 4.186]	0.044
18	M	18	Y	67.81	1.69	3063	0.84	0.129	22	[1.402, 5.513]	0.060
19	F	22	Y	70.31	1.63	3057	0.76	0.092	20	[0.679, 3.506]	0.024
20	F	38	M	53.77	1.68	2808	0.82	0.118	21	[1.038, 9.157]	0.063
21	F	37	M	54.84	1.59	3371	0.96	0.065	19	[1.764, 5.019]	0.093
22	F	38	M	59.01	1.68	2935	0.89	0.092	18	[0.982, 7.018]	0.036
23	F	43	M	64.09	1.73	2748	0.93	0.153	20	[3.589, 7.387]	0.109
24	M	60	M	79.48	1.83	2318	0.95	0.058	21	[0.576, 4.300]	0.056
25	M	27	Y	64.09	1.80	2908	0.88	0.128	21	[1.951, 6.715]	0.040
26	F	44	M	56.20	1.57	2520	0.85	0.058	22	[0.560, 2.773]	0.014
27	M	61	M	92.28	1.82	2999	0.95	0.038	15	[1.419, 5.281]	0.026
28	M	55	M	79.62	1.71	2945	0.96	0.068	17	[1.978, 6.334]	0.117
29	M	27	Y	88.67	1.77	3083	0.87	0.099	21	[1.436, 5.582]	0.044
Mean				72.83	1.71	2884	0.90	0.086	20	2.999	0.062
SD				12.86	0.08	388	0.07	0.036	3	1.083	0.031

Body mass in kilograms;

Body height in meters;

Age category: Y for young adults, and M for middle-aged adults;

K_{FL} : Number of hip joint quasi-stiffness values during hip flexion, both sides included;Mean R^2 : Mean R-squared value of the curve fitting;

Mean RMSE: Mean root mean squared error of the curve fitting (Nm/kg);

#Frames: Average number of frames used for the curve fitting for each K_{FL} value; K_{FL} range: Range of K_{FL} (Nm/kg/rad);Mean W_{FL} : Average mechanical work at the hip joint during hip flexion (J/kg);

SD: Standard deviation;

Sampling frequency: 150 Hz