

## Appendix C

# Hill Muscles Properties

The properties of the muscles shown in Figure C.1 are listed below for an adult like model and for the four robots investigated in this thesis.

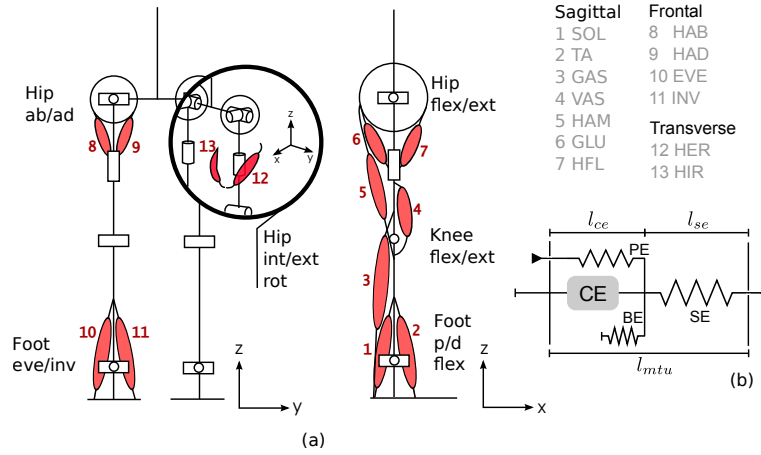


Figure C.1: Muscles acting on the leg joints. [10]

### C.1 Adult-like model [8] [23]

Table C.1: Leg muscles properties for an adult-like model (1)

	SOL	TA	GAS	VAS	HAM	GLU
$F_{max}$ [N]	4000	800	1500	6000	3000	1500
$v_{max}$ [ $l_{opt}/s$ ]	6	12	12	12	12	12
$l_{opt}$ [cm]	4	6	5	8	10	11
$l_{slack}$ [cm]	26	24	40	23	31	13
$r_0$ [cm]	5	4	5(a)	6	5(k)	10
$\phi_{max}$ [deg]	20	-10	5(k) 20(a) 40(k)	15	8(h) 0(k) -(h)	-
$\phi_{ref}$ [deg]	-10	20	-10(a) 15(k)	55	0(k) -25(h)	-30
$\rho$ [-]	0.5	0.7	0.7(a) 0.7(k)	0.7	0.7(k) 0.7(h)	0.5
m [kg]	0.68	0.2	0.32	2.04	1.27	0.7
$\lambda$ [-]	0.81	0.7	0.54	0.5	0.44	0.5

Table C.2: Leg muscles properties for an adult-like model (2)

	HFL	HAB	HAD	HER	HIR	EVE	INV
$F_{max}$ [N]	2000	3000	4500	500	800	700	900
$v_{max}$ [ $l_{opt}/s$ ]	12	12	12	12	12	12	12
$l_{opt}$ [cm]	11	9	10	4	8	5	5
$l_{slack}$ [cm]	10	7	18	5	7	25	30
$r_0$ [cm]	10	6	3	4	3	3	2
$\phi_{max}$ [deg]	-	-	-	-	-	-10	5
$\phi_{ref}$ [deg]	0	-10	-15	10	-20	-5	-10
$\rho$ [-]	0.5	0.7	1	1	0.7	0.7	0.7
m [kg]	0.93	1.14	1.91	0.09	0.27	0.15	0.19
$\lambda$ [-]	0.5	0.5	0.57	0.5	0.5	0.57	0.55

## C.2 NAO model

Table C.3: Leg muscles properties for the NAO model

	SOL	TA	GAS	VAS	HAM	GLU
$F_{max}$ [N]	250	50	93.7	375	187.5	93.75
$v_{max}$ [ $l_{opt}/s$ ]	10.4	20.8	20.8	20.8	20.8	20.8
$l_{opt}$ [cm]	1.3	1.9	1.6	2.6	3.3	3.6
$l_{slack}$ [cm]	8.5	7.9	13.2	7.5	10.2	4.2
$r_0$ [cm]	1.6	1.3	1.6(a) 1.6(k)	1.9	1.6(k) 2.6(h)	3.3
$\phi_{max}$ [deg]	20	-10	20(a) 40(k)	15	0(k) -(h)	-
$\phi_{ref}$ [deg]	-10	20	-10(a) 15(k)	55	0(k) -25(h)	-30
$\rho$ [-]	0.5	0.7	0.7(a) 0.7(k)	0.7	0.7(k) 0.7(h)	0.5
m [kg]	0.04	0.01	0.02	0.12	0.07	0.04
$\lambda$ [-]	0.81	0.7	0.54	0.5	0.44	0.5

Table C.4: Leg muscles properties for the NAO model (2)

	HFL	HAB	HAD	HER	HIR	EVE	INV
$F_{max}$ [N]	125	187.5	281.2	31.2	50	43.7	56.2
$v_{max}$ [ $l_{opt}/s$ ]	20.8	20.8	20.8	20.8	20.8	20.8	20.8
$l_{opt}$ [cm]	3.6	2.9	3.3	1.3	2.6	1.6	1.6
$l_{slack}$ [cm]	3.3	2.3	5.9	1.6	2.3	8.2	9.9
$r_0$ [cm]	3.3	1.9	0.9	1.3	0.9	0.9	0.6
$\phi_{max}$ [deg]	-	-	-	-	-	-10	5
$\phi_{ref}$ [deg]	0	-10	-15	10	-20	-5	-10
$\rho$ [-]	0.5	0.7	1	1	0.7	0.7	0.7
m [kg]	0.05	0.07	0.11	0.005	0.01	0.009	0.01
$\lambda$ [-]	0.5	0.5	0.57	0.5	0.5	0.57	0.55

### C.3 CoMan model

Table C.5: Leg muscles properties for the CoMan model (1)

	SOL	TA	GAS	VAS	HAM	GLU
$F_{max}$ [N]	1550	310	581.2	2325	1162.5	581.2
$v_{max}$ [ $l_{opt}/s$ ]	8.3	16.6	16.6	16.6	16.6	16.6
$l_{opt}$ [cm]	2.0	3.1	2.6	4.1	5.2	5.7
$l_{slack}$ [cm]	13.5	12.4	20.8	11.9	16.1	6.7
$r_0$ [cm]	2.6	2.0	2.6(a) 2.6(k)	3.1	2.6(k) 4.1(h)	5.2
$\phi_{max}$ [deg]	20	-10	20(a) 40(k)	15	0(k) -(h)	-
$\phi_{ref}$ [deg]	-10	20	-10(a) 15(k)	55	0(k) -25(h)	-30
$\rho$ [-]	0.5	0.7	0.7(a) 0.7(k)	0.7	0.7(k) 0.7(h)	0.5
m [kg]	0.26	0.07	0.12	0.79	0.49	0.27
$\lambda$ [-]	0.81	0.7	0.54	0.5	0.44	0.5

Table C.6: Leg muscles properties for the CoMan model (2)

	HFL	HAB	HAD	HER	HIR	EVE	INV
$F_{max}$ [N]	775	1162.5	1743.7	193.7	310	271.2	348.7
$v_{max}$ [ $l_{opt}/s$ ]	16.6	16.6	16.6	16.6	16.6	16.6	16.6
$l_{opt}$ [cm]	5.7	4.6	5.2	2.0	4.1	2.6	2.6
$l_{slack}$ [cm]	5.2	3.6	9.3	2.6	3.6	13	15.6
$r_0$ [cm]	5.2	3.1	1.5	2.0	1.5	1.5	1.0
$\phi_{max}$ [deg]	-	-	-	-	-	-10	5
$\phi_{ref}$ [deg]	0	-10	-15	10	-20	-5	-10
$\rho$ [-]	0.5	0.7	1	1	0.7	0.7	0.7
m [kg]	0.36	0.44	0.74	0.03	0.10	0.05	0.07
$\lambda$ [-]	0.5	0.5	0.57	0.5	0.5	0.57	0.55

## C.4 WalkMan model

Table C.7: Leg muscles properties for the WalkMan model (1)

	SOL	TA	GAS	VAS	HAM	GLU
$F_{max}$ [N]	7100	1420	2662.5	10650	5325	2662.5
$v_{max}$ [ $l_{opt}/s$ ]	5.7	11.4	11.4	11.4	11.4	11.4
$l_{opt}$ [cm]	4.4	6.6	5.5	8.8	11.0	12.1
$l_{slack}$ [cm]	28.6	26.4	44.0	25.3	34.1	14.3
$r_0$ [cm]	5.5	4.4	5.5	6.6	5.5	11.0
$\phi_{max}$ [deg]	20	-10	5.5(k) 20(a) 40(k)	15	8.8(h) 0(k) -(h)	-
$\phi_{ref}$ [deg]	-10	20	-10(a) 15(k)	55	0(k) -25(h)	-30
$\rho$ [-]	0.5	0.7	0.7(a) 0.7(k)	0.7	0.7(k) 0.7(h)	0.5
m [kg]	1.20	0.35	0.56	3.62	2.25	1.24
$\lambda$ [-]	0.81	0.7	0.54	0.5	0.44	0.5

Table C.8: Leg muscles properties for the WalkMan model (2)

	HFL	HAB	HAD	HER	HIR	EVE	INV
$F_{max}$ [N]	3550	5325	7987.5	887.5	1420	1242.5	1597.5
$v_{max}$ [ $l_{opt}/s$ ]	11.4	11.4	11.4	11.4	11.4	11.4	11.4
$l_{opt}$ [cm]	12.1	9.9	11.0	4.4	8.8	5.5	5.5
$l_{slack}$ [cm]	11.0	7.7	19.8	5.5	7.7	27.5	33
$r_0$ [cm]	11.0	6.6	3.3	4.4	3.3	3.3	2.2
$\phi_{max}$ [deg]	-	-	-	-	-	-10	5
$\phi_{ref}$ [deg]	0	-10	-15	10	-20	-5	-10
$\rho$ [-]	0.5	0.7	1	1	0.7	0.7	0.7
m [kg]	1.6	2.0	3.3	0.1	0.4	0.2	0.3
$\lambda$ [-]	0.5	0.5	0.57	0.5	0.5	0.57	0.55

## C.5 Atlas model

Table C.9: Leg muscles properties for the Atlas model (1)

	SOL	TA	GAS	VAS	HAM	GLU
$F_{max}$ [N]	8600	1720	3225	12900	6450	3225
$v_{max}$ [ $l_{opt}/s$ ]	6.1	12.3	12.3	12.3	12.3	12.3
$l_{opt}$ [cm]	3.7	5.6	4.7	7.5	9.4	10.3
$l_{slack}$ [cm]	24.4	22.5	37.6	21.6	29.1	12.2
$r_0$ [cm]	4.7	3.7	4.7	5.6	4.7	9.4
$\phi_{max}$ [deg]	20	-10	4.7(k) 20(a)	15	7.5(h) 0(k)	-
$\phi_{ref}$ [deg]	-10	20	40(k) -10(a)	55	-(h) 0(k)	-30
$\rho$ [-]	0.5	0.7	15(k) 0.7(a)	0.7	-25(h) 0.7(k)	0.5
m [kg]	1.4	0.4	0.7(k)	4.3	0.7(h)	1.5
$\lambda$ [-]	0.81	0.7	0.54	0.5	0.44	0.5

Table C.10: Leg muscles properties for the Atlas model (2)

	HFL	HAB	HAD	HER	HIR	EVE	INV
$F_{max}$ [N]	4300	6450	9675	1075	1720	1505	1935
$v_{max}$ [ $l_{opt}/s$ ]	12.3	12.3	12.3	12.3	12.3	12.3	12.3
$l_{opt}$ [cm]	10.3	8.4	9.4	3.7	7.5	4.7	4.7
$l_{slack}$ [cm]	9.4	6.5	16.9	4.7	6.5	23.5	28.2
$r_0$ [cm]	9.4	5.6	2.8	3.7	2.8	2.8	1.8
$\phi_{max}$ [deg]	-	-	-	-	-	-10	5
$\phi_{ref}$ [deg]	0	-10	-15	10	-20	-5	-10
$\rho$ [-]	0.5	0.7	1	1	0.7	0.7	0.7
m [kg]	1.9	2.4	4.1	0.1	0.5	0.3	0.4
$\lambda$ [-]	0.5	0.5	0.57	0.5	0.5	0.57	0.55