Arm posture development during early stages of independent walking

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Introduction

Research on the course of arm posture and movement during the development of independent walking is sparse. At the onset of independent walking, toddlers do not display the reciprocal arm-swing that is typically observed in adults (Ledebt, 2000; Kubo & Ulrich, 2006). Instead, toddlers display little to no movement in their arms by flexing their shoulders and elbows and positioning their arms abduct (Ledebt, 2000). This is known as the 'high guard' position.

In toddlers, high guard is thought to counteract the upper trunk rotation by increasing the moment of inertia of the arm-upper trunk complex around the axis of the trunk segment (Kubo & Ulrich, 2006). This will allow toddlers to achieve postural stability and balance control at the onset of walking. As toddlers become more comfortable with their walk their step width decreases and the position of their arms lower and then progressively move (Ledebt, 2000). The first movements are observed at the shoulder joints and then at the elbow this called flexed movement (Ledebt, 2000). Ledebt (2000) observed that when reciprocal arm-swing was present in toddlers they would alternate with flexed movements, suggesting that the development of arm posture may not be successive. Additionally, Ledebt (2000) failed to mention the possibility of asymmetrical arm movement. To further explore the developmental progression of arm posture and movement, it seems necessary to examine arm posture in greater detail analyzing each arm separately.

The purpose of this study was to examine the developmental changes in arm posture and movement in the left and right arm separately. We hypothesized that the arm

position at the onset of walking would be high guard, and as the toddlers become more comfortable with walking, they will change from middle guard to low guard. Additionally, we hypothesized that the development in arm posture and movements will be symmetrical; the same patterns will be observed in both the left and right arm.

Methods

Participants

Seven toddlers with typical development were observed for this study. Arm posture and movements were coded from video recordings taken once a month, over the course of 6 months for each toddler. The time interval between each visit was one month. For two toddlers, data from visits four and six were insufficient to observe arm posture. Mean ages at the first and last visit were 12 months 6 days, and 23 months 1 day, respectively.

Procedure

At each visit, toddlers walked for 3-5 trials barefoot from one end of a mat to the other. Analysis included only trials of six or more consecutive steps without incidences of falling or walking off the walkway. The frame number at which the walking trial began and ended was recorded. The walking trail began when the toddler's whole body was visible and their first stepping foot completely left the ground. The trial ended when the toddlers last stepping foot completely planted on the ground. Last steps were recorded before the toddler came into contact with an object or person.

Measures

Five categories of arm posture and movement were coded for: high guard, middle guard, low guard, flexed movement, and elbow swing. The definitions for high, middle, and low guard, and flexed movements were similar to those used in Ledebt et al's (2000) study:

(1) High guard: arms High guard: arms fixed with external rotation at the shoulders and flexed elbows where the thumbs were aligned higher than the shoulder.
(2) Middle guard: arms fixed with flexed elbows where the hands were between the shoulder and the skinniest part of the waist.
(3) Low guard: arms extended along the body without noticeable movement.
(4) Flexed movement: the main movements were observed at the shoulder joint and the elbow was flexed. This category includes back and forth as well as circumdunction movements.

Elbow swing was added after it was observed in 2 children during coding. Elbow swing is defined as:

(5) Elbow swing: main movements were observed at the elbow and the shoulders were flexed.

Arm posture and movement for the left arm and right arm were coded for separately during each video frame, which represented $1/30^{th}$ of a second. Every time a change was observed in arm position, the frame number and new arm position were recorded. The total time, in seconds and percent, that each arm was held in a posture was calculated for each walking trial. For every visit, the average total time and percent time the toddler spent in each arm position was calculated.

Results

The results for the average time that the left and the right arm spent in each of the six arm posture categories as a function of months of independent walking are shown in Fig. 1.

The results for the average percent time of the left and right arm for the six arm posture categories as a function of months of independent walking are shown in Fig. 2.

References

Kubo, M., & Ulrich, B. (2006). A biomechanical analysis of the 'high guard' position of arms during walking in toddlers. *Infant Behavior & Development, 29*, 509-517.

Ledebt, A. (2000). Changes in arm posture during the early acquisition of walking. *Infant Behavior & Development, 23*, 79-89.

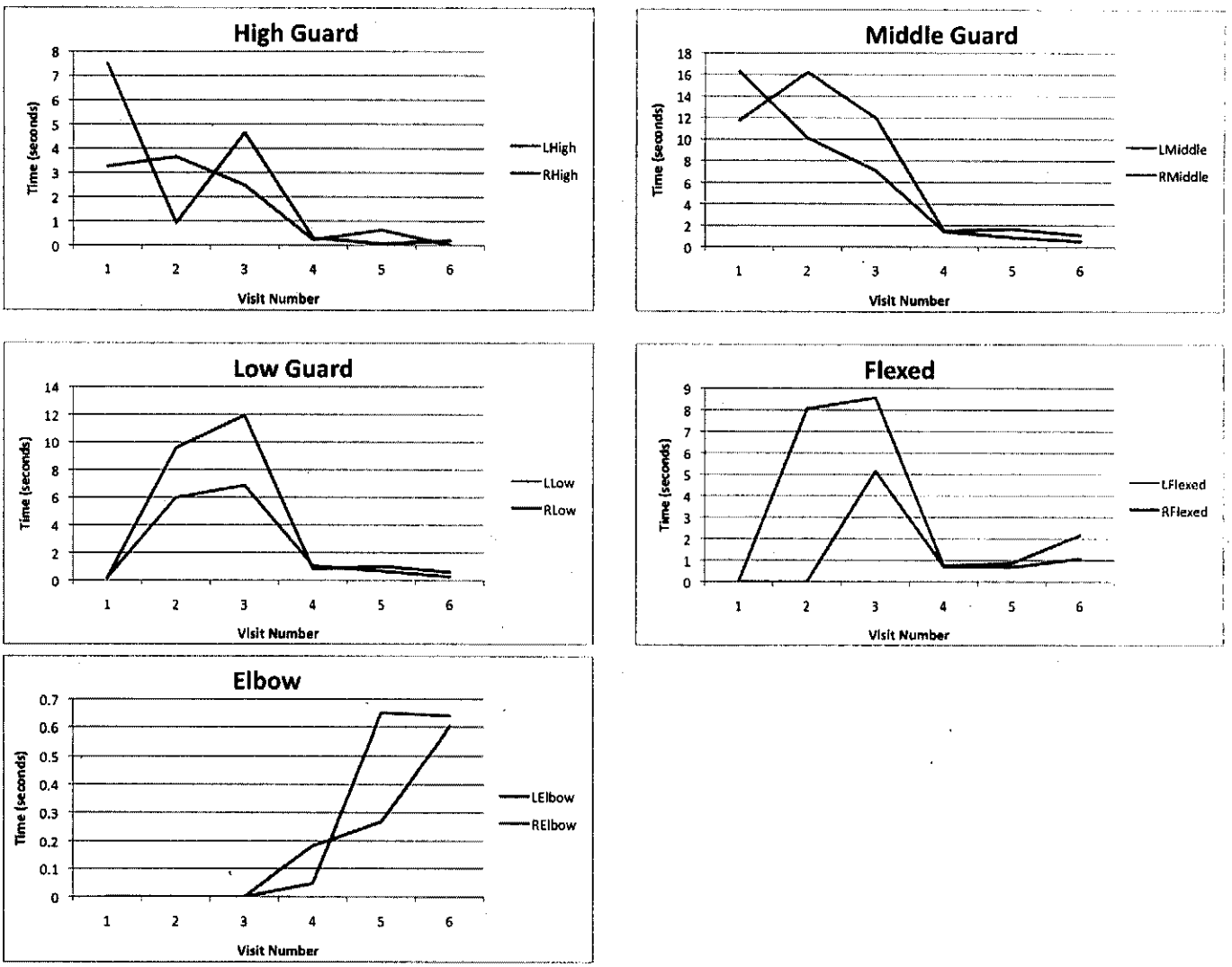

Figure 1. Average time for left and right arm in each arm posture category as a function of months of independent walking.

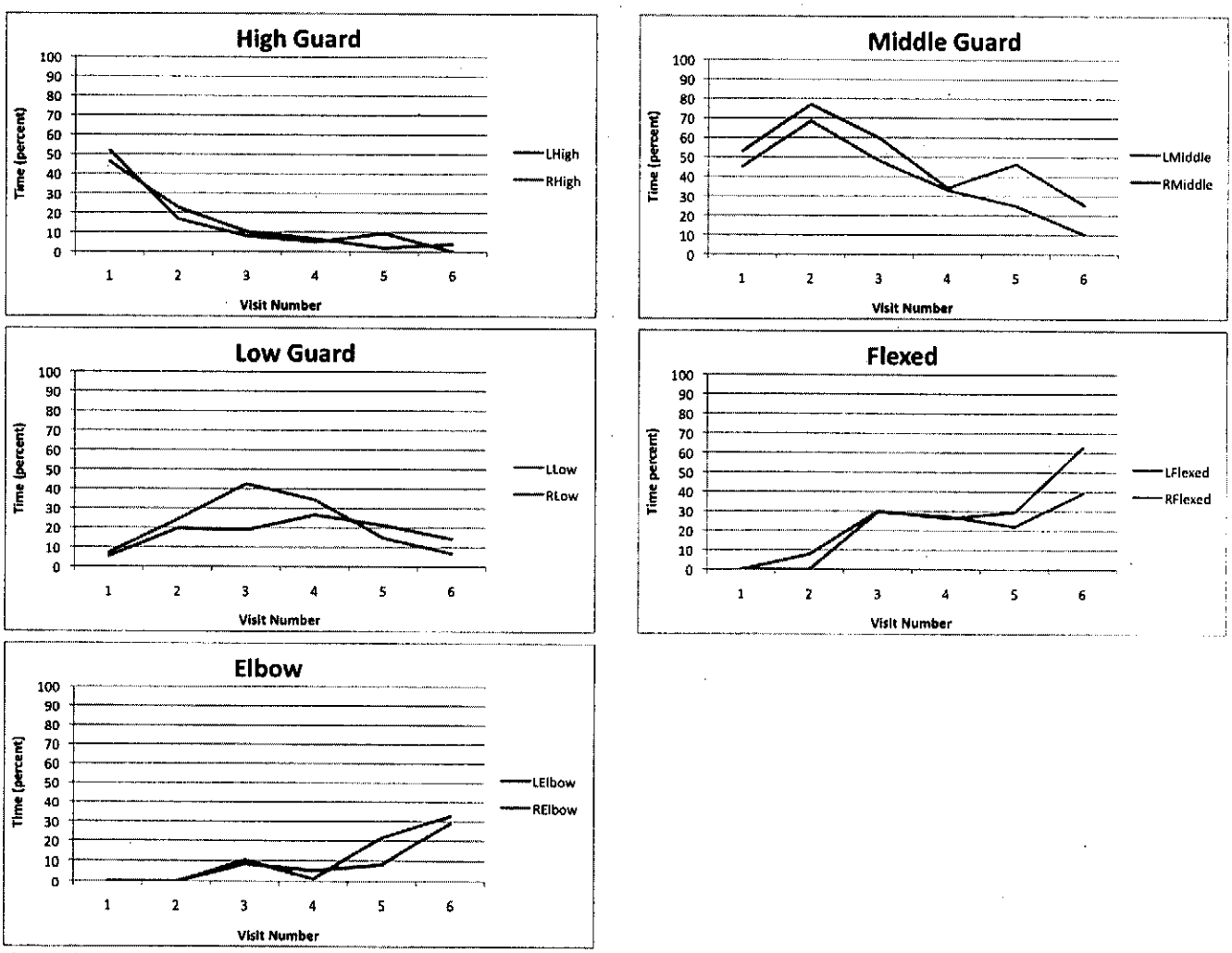

Figure 2. Total percentage of time for left arm and right arm in each arm posture category as a function of months of independent walking.

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Research Summary: I observed changes in arm posture and movement in 7 toddlers who had just begun to walk. Arm postures and movements were coded from video recordings that were taken once a month, over the course of 4-6 months for each toddler.

Each video recording contained 3-5 trials of the toddler walking barefoot from one end of a mat to the other. Arm posture and movement for the left arm and right arm were coded for separately during each video frame, which represented 1/30th of a second.

Five categories of arm posture and movement were coded for: high guard, middle guard, low guard, flexed movement, and elbow swing. The definitions for high, middle, and low guard, and flexed movements were similar to those used in Ledebt et al's (2000) study:

(1) High guard: arms High guard: arms fixed with external rotation at the shoulders and flexed elbows where the thumbs were aligned higher than the shoulder.
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Elbow swing was added after it was observed in 2 children during coding. Elbow swing is defined as:

(5) Elbow swing: main movements were observed at the elbow and the shoulders were flexed.

The total time, in seconds and percent, that each arm was held in a posture was calculated for each walking trial. For every visit, the average total time and percent time the toddler spent in each arm position was calculated. Figure 1 is an example of the coding recorded for one toddler's visit.

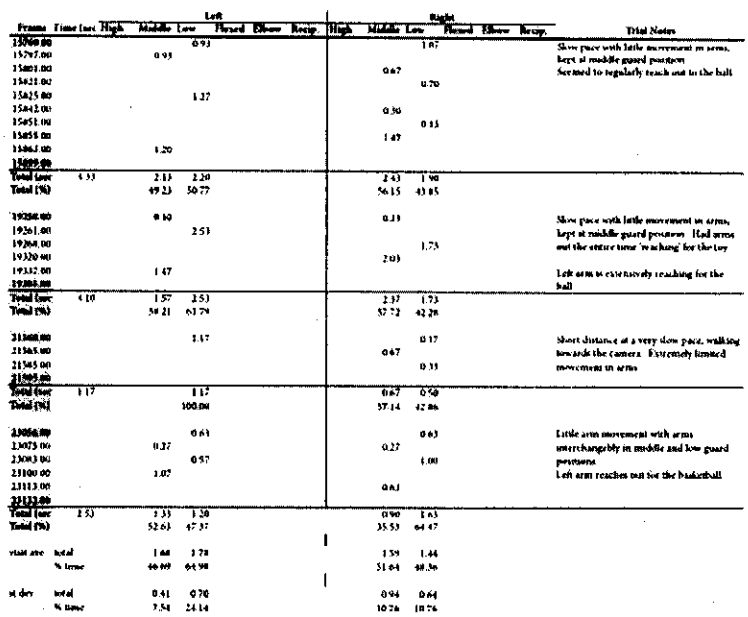

Figure 1. Arm posture and movement coding for 4 trials in one visit.

The average total time and percent time for each arm position of every trial was compiled for every trial. This allowed us to compare the average time spent in each arm posture, for both arms, over the course of the 6 trials. The profiles for the 4 arm categories, high guard, middle guard, low guard, and flexed movements were similar to those found in Ledebt et al.'s (2000) study. However, to our knowledge, this current study is the first study to look at the development arm posture for each arm separately. For each arm posture category, the left and right arm had similar profiles. The following graphs show the individual profiles of each arm for the arm posture categories over the course of 6 visits.

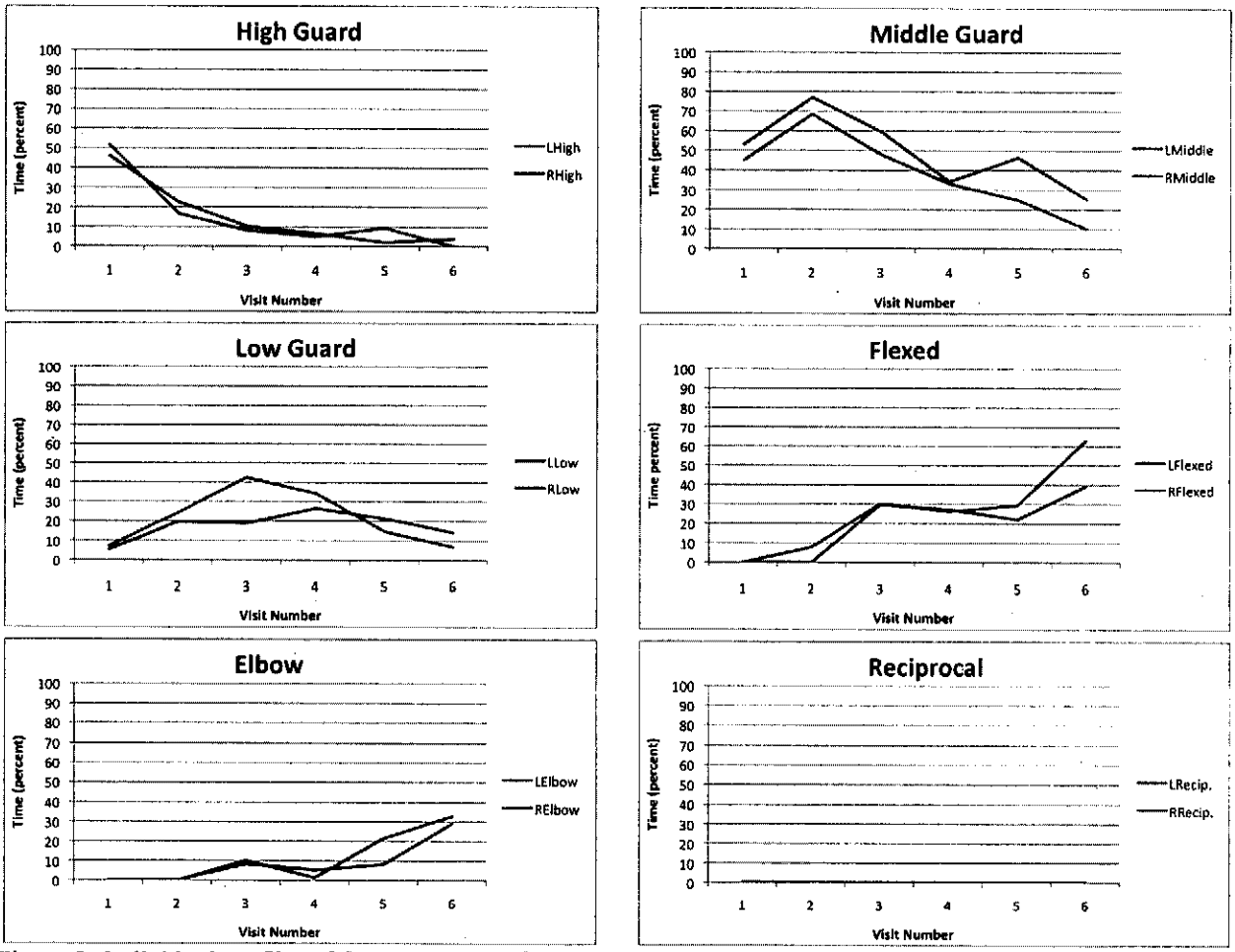

Figure 2. Individual profiles of the percentage of time spent in the arm posture categories for each arm.

	subject#	Trial#	visit#	LHigh	LMiddle	LLow	LFlexed	Lelbow	LRecip.	RHigh	RMiddle	RLow	RFlexed	RElbow	RRecip.
Average	10	107	1	77.16	22.84	0.00	0.00	0.00	0.00	36.29	63.71	0.00	0.00	0.00	0.00
	12	130	1	63.35	36.65	0.00	0.00	0.00	0.00	77.06	41.90	0.00	0.00	0.00	0.00
	14	148	1	49.33	50.67	0.00	0.00	0.00	0.00	44.99	55.01	0.00	0.00	0.00	0.00
	16	174	1	100.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
	18	191	1	6.04	70.23	51.16	0.00	0.00	0.00	0.00	74.98	37.54	0.00	0.00	0.00
	20	210	1	4.49	97.75	0.00	0.00	0.00	0.00	36.09	63.91	0.00	0.00	0.00	0.00
	22	227	1	62.55	37.45	0.00	0.00	0.00	0.00	28.49	71.51	0.00	0.00	0.00	0.00
			average	51.85	45.08	7.31	0.00	0.00	0.00	46.13	53.00	5.36	0.00	0.00	0.00
			stdev	35.48	31.87	19.34	0.00	0.00	0.00	32.91	25.81	14.19	0.00	0.00	0.00
	10	108	2	0.00	66.71	33.29	0.00	0.00	0.00	8.89	94.10	7.36	0.00	0.00	0.00
	12	131	2	4.95	79.89	47.80	0.00	0.00	0.00	16.30	75.98	43.75	0.00	0.00	0.00
	14	149	2	17.41	86.94	0.00	0.00	0.00	0.00	15.32	84.68	0.00	0.00	0.00	0.00
	16	175	2	37.95	57.13	19.68	0.00	0.00	0.00	47.35	52.65	0.00	0.00	0.00	0.00
	18	192	2	37.06	43.18	29.02	0.00	0.00	0.00	45.15	56.10	20.08	0.00	0.00	0.00
	20	212	2	19.47	47.39	33.51	54.77	0.00	0.00	0.00	87.96	60.20	0.00	0.00	0.00
	22	228	2	0.00	98.08	5.77	0.00	0.00	0.00	25.25	87.81	5.66	0.00	0.00	0.00
			average	16.69	68.47	24.15	7.82	0.00	0.00	22.61	77.04	19.58	0.00	0.00	0.00
			stdev	16.18	20.67	16.81	20.70	0.00	0.00	17.88	16.43	23.61	0.00	0.00	0.00
	10	109	3	0.00	46.69	64.98	0.00	0.00	0.00	0.00	51.64	48.36	0.00	0.00	0.00
	12	132	3	0.00	50.99	61.76	0.00	0.00	0.00	0.00	55.07	44.93	0.00	0.00	0.00
	14	150	3	11.90	94.05	0.00	0.00	0.00	0.00	8.93	90.12	6.36	0.00	0.00	0.00
	16	176	3	9.09	0.00	0.00	97.73	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
	18	193	3	20.00	73.78	29.33	0.00	0.00	0.00	32.31	89.23	0.00	0.00	0.00	0.00
	20	213	3	15.43	35.72	41.35	55.16	0.00	0.00	30.38	68.53	31.73	31.89	0.00	0.00
	22	229	3	0.00	35.40	100.00	57.78	71.43	0.00	0.00	63.61	0.00	75.00	59.18	0.00
			average	8.06	48.09	42.49	30.09	10.20	0.00	10.23	59.74	18.77	29.56	8.45	0.00
			stdev	8.24	30.03	36.45	39.98	27.00	0.00	14.80	30.39	22.13	41.89	22.37	0.00
	10	110	4	0.00	0.00	100.00	0.00	0.00	0.00	0.00	44.99	55.01	0.00	0.00	0.00
	12	133	4	0.00	89.47	10.53	0.00	0.00	0.00	0.00	34.99	65.01	0.00	0.00	0.00
	14	151	4	23.85	76.15	0.00	0.00	0.00	0.00	27.60	72.40	0.00	0.00	0.00	
	16	177	4	0.00	0.00	0.00	93.19	6.81	0.00	0.00	0.00	0.00	72.89	27.11	0.00
	22	230	4	1.15	0.00	60.96	37.89	0.00	0.00	5.17	18.87	12.62	63.34	0.00	0.00
			average	5.00	33.12	34.30	26.22	1.36	0.00	6.55	34.25	26.53	27.25	5.42	0.00
			stdev	10.55	45.60	44.57	40.88	3.04	0.00	11.98	27.30	31.20	37.46	12.12	0.00
	10	111	5	63.40	9.54	15.04	0.00	12.03	0.00	0.00	18.28	69.69	0.00	12.03	0.00
	12	134	5	0.00	1.12	0.00	5.13	93.75	0.00	0.00	65.52	15.51	8.37	10.61	0.00
	14	152	5	0.00	46.11	53.89	0.00	0.00	0.00	0.38	92.26	7.37	0.00	0.00	0.00
	16	178	5	0.00	0.00	0.00	55.17	44.83	0.00	0.00	0.00	0.00	65.24	34.76	0.00
	18	195	5	0.00	55.91	24.15	19.94	0.00	0.00	6.82	60.41	20.77	11.99	0.00	0.00

20	215		5	0.00	0.00	0.00	100.00	0.00	0.00	0.00	38.26	0.00	61.74	0.00	0.00
22	231		5	2.41	61.75	10.84	25.00	0.00	0.00	6.62	50.40	35.99	6.99	0.00	0.00
		average		9.40	24.92	14.85	29.32	21.51	0.00	1.97	46.45	21.33	22.05	8.20	0.00
		stdev		23.83	28.31	19.53	36.69	35.83	0.00	3.25	30.80	24.81	28.66	12.88	0.00
10	112		6	0.00	27.68	6.23	40.63	71.24	0.00	8.45	15.86	9.61	47.09	61.55	0.00
12	135		6	0.00	0.00	0.00	82.27	17.73	0.00	0.00	0.00	0.00	78.61	21.39	0.00
14	153		6	0.00	9.29	4.29	86.43	0.00	0.00	0.00	67.86	32.14	0.00	0.00	0.00
16	179		6	0.00	0.00	0.00	24.47	75.53	0.00	0.00	0.00	0.00	37.85	62.15	0.00
22	232		6	0.00	13.96	23.89	81.08	0.00	0.00	10.87	42.79	30.02	32.62	0.00	0.00
		average		0.00	10.19	6.88	62.98	32.90	0.00	3.86	25.30	14.35	39.23	29.02	0.00
		stdev		0.00	11.50	9.89	28.43	37.69	0.00	5.36	29.52	15.78	28.27	31.22	0.00

	subject#	Trial#	visit#		LHigh	LMiddle	LLow	LFlexed	Lelbow	LRecip.	RHigh	RMiddle	RLow	RFlexed	RElbow	RRecip.
TotalTime	10	107		1	8.93	2.86	0.00	0.00	0.00	0.00	4.51	7.28	0.00	0.00	0.00	0.00
	12	130		1	2.72	1.48	0.00	0.00	0.00	0.00	3.28	1.70	0.00	0.00	0.00	0.00
	14	148		1	2.20	2.87	0.00	0.00	0.00	0.00	2.76	2.31	0.00	0.00	0.00	0.00
	16	174		1	3.71	0.00	0.00	0.00	0.00	0.00	3.71	0.00	0.00	0.00	0.00	0.00
	18	191		1	0.37	2.43	1.39	0.00	0.00	0.00	0.00	2.20	1.40	0.00	0.00	0.00
	20	210		1	0.40	6.72	0.00	0.00	0.00	0.00	2.17	4.75	0.00	0.00	0.00	0.00
	22	227		1	4.13	2.38	0.00	0.00	0.00	0.00	2.03	4.48	0.00	0.00	0.00	0.00
			average		3.26	16.30	0.20	0.00	0.00	0.00	7.50	11.74	0.20	0.00	0.00	0.00
			stdev		2.94	35.97	0.52	0.00	0.00	0.00	12.69	23.13	0.53	0.00	0.00	0.00
	10	108		2	0.00	2.63	1.29	0.00	0.00	0.00	0.27	3.71	0.30	0.00	0.00	0.00
	12	131		2	0.30	3.71	3.92	0.00	0.00	0.00	0.52	3.60	3.83	0.00	0.00	0.00
	14	149		2	2.22	10.77	0.00	0.00	0.00	0.00	1.95	10.48	0.00	0.00	0.00	0.00
	16	175		2	1.89	3.38	1.23	0.00	0.00	0.00	2.39	3.18	0.00	0.00	0.00	0.00
	18	192		2	0.96	1.68	0.94	0.00	0.00	0.00	1.32	1.98	0.73	0.00	0.00	0.00
	20	212		2	0.73	1.29	1.03	1.62	0.00	0.00	0.00	2.51	1.97	0.00	0.00	0.00
	22	228		2	0.00	3.19	0.20	0.00	0.00	0.00	0.83	2.86	0.18	0.00	0.00	0.00
			average		3.65	10.12	5.99	8.05	0.00	0.00	0.92	16.20	9.58	0.00	0.00	0.00
			stdev		7.02	16.74	12.20	20.61	0.00	0.00	0.97	31.77	22.37	0.00	0.00	0.00
	10	109		3	0.00	1.68	1.78	0.00	0.00	0.00	0.00	1.59	1.44	0.00	0.00	0.00
	12	132		3	0.00	2.11	2.90	0.00	0.00	0.00	0.00	2.36	2.13	0.00	0.00	0.00
	14	150		3	0.90	6.78	0.00	0.00	0.00	0.00	0.67	6.53	0.42	0.00	0.00	0.00
	16	176		3	0.27	0.00	0.00	3.28	0.00	0.00	0.00	0.00	0.00	3.35	0.00	0.00
	18	193		3	0.43	2.33	0.70	0.00	0.00	0.00	0.70	2.71	0.00	0.00	0.00	0.00
	20	213		3	0.40	1.01	1.43	1.49	0.00	0.00	0.80	1.93	1.10	0.82	0.00	0.00
	22	229		3	0.00	0.55	1.27	0.87	1.17	0.00	0.00	0.92	0.00	0.97	0.97	0.00
			average		2.49	7.09	6.88	8.56	0.00	0.00	4.65	11.95	5.26	5.15	0.00	0.00
			stdev		5.71	12.81	15.23	20.58	0.00	0.00	11.35	25.03	11.70	11.85	0.00	0.00
	10	110		4	0.00	0.00	3.98	0.00	0.00	0.00	0.00	1.63	2.34	0.00	0.00	0.00
	12	133		4	0.00	2.10	0.23	0.00	0.00	0.00	0.00	0.78	1.54	0.00	0.00	0.00
	14	151		4	1.12	5.02	0.00	0.00	0.00	0.00	1.41	4.73	0.00	0.00	0.00	0.00
	16	177		4	0.00	0.00	0.00	3.01	0.24	0.00	0.00	0.00	0.00	2.33	0.91	0.00
	22	230		4	0.02	0.00	1.13	0.73	0.00	0.00	0.10	0.33	0.24	1.21	0.00	0.00
			average		0.23	1.42	1.07	0.75	0.05	0.00	0.30	1.50	0.83	0.71	0.18	0.00
			stdev		0.50	2.21	1.69	1.30	0.11	0.00	0.62	1.91	1.06	1.05	0.41	0.00
	10	111		5	4.39	0.52	0.82	0.00	0.63	0.00	0.00	1.20	4.53	0.00	0.63	0.00
	12	134		5	0.00	0.03	0.00	0.13	2.49	0.00	0.00	1.71	0.46	0.21	0.27	0.00
	14	152		5	0.00	2.32	2.59	0.00	0.00	0.00	0.02	4.47	0.42	0.00	0.00	0.00
	16	178		5	0.00	0.00	0.00	1.55	1.43	0.00	0.00	0.00	0.00	2.01	0.97	0.00
	18	195		5	0.00	1.64	1.04	0.86	0.00	0.00	0.29	1.84	0.90	0.51	0.00	0.00
	20	215		5	0.00	0.00	0.00	2.98	0.00	0.00	0.00	1.17	0.00	1.81	0.00	0.00
	22	231		5	0.07	1.67	0.30	0.55	0.00	0.00	0.15	1.29	0.93	0.22	0.00	0.00
			average		0.64	0.88	0.68	0.87	0.65	0.00	0.07	1.67	1.03	0.68	0.27	0.00
			stdev		1.65	0.97	0.94	1.08	0.97	0.00	0.11	1.37	1.59	0.86	0.39	0.00
	10	112		6	0.00	1.71	0.35	0.83	1.00	0.00	0.63	0.83	0.60	0.91	0.92	0.00
	12	135		6	0.00	0.00	0.00	2.76	0.54	0.00	0.00	0.00	0.00	2.66	0.64	0.00
	14	153		6	0.00	0.43	0.20	4.03	0.00	0.00	0.00	3.17	1.50	0.00	0.00	0.00
	16	179		6	0.00	0.00	0.00	0.55	1.65	0.00	0.00	0.00	0.00	0.75	1.45	0.00
	22	232		6	0.00	0.47	0.80	2.70	0.00	0.00	0.33	1.46	0.98	1.08	0.00	0.00
			average		0.00	0.52	0.27	2.17	0.64	0.00	0.19	1.09	0.62	1.08	0.60	0.00

stdev	0.00	0.70	0.33	1.46	0.70	0.00	0.28	1.31	0.65	0.97	0.62	0.00	