Postural Analysis of Paramedics Using Stairchairs

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Abstract. The objective of this study was to investigate the working postures, applied forces, and subjective ratings of perceived exertion of paramedics required to transport a victim down a flight of stairs using different designs of stairchairs. A total of six different models of stairchairs were evaluated with three different carrying positions (i.e., follower, leader facing backward, and leader facing forward). Results indicate that stairchairs designed to have the stairwell support the weight of the victim reduced the ratings of perceived exertion and can influence the applied force required to complete the task.

INTRODUCTION

A normal part of a paramedic's job is to lift, carry, and handle ill and injured patients under difficult circumstances. Unfortunately, high back injury rates have been reported for paramedics (Hogya and Ellis, 1990). Awkward body postures have been identified as one of the main contributors to the reduction of the human musculoskeletal system's capacity (Wiker, 1989). Studies conducted by Lavender et al. (2000a; 2000b) identified the transporting of a victim down a flight of stairs using a stairchair as a frequently performed strenuous emergency rescue tasks. With this in mind, the objective of this study was to investigate the working postures, applied forces, and subjective ratings of perceived exertion of paramedics required to transport a victim down a flight of stairs and around a landing using six different designs of stairchairs.

METHODS AND PROCEDURES

Eight male paramedics with age ranges between 20 and 47 years (mean 31 and std. dev. 8) volunteered to participate in this study. The mean height and weight of these individuals were 1.81 m (range: 1.71-1.98 m) and 101 kg (range: 58-123 kg), respectively.

The simulated task included the descent of a staircase (20 steps) and the negotiation of a landing requiring a 90? turn. The staircase width was 840 mm and each step had a 180 mm rise and a 280 mm run. Four video cameras were positioned to provide the best orthogonal views to the sagittal and frontal planes of each subject (Lavender et al., 2000a, 2000b). Trunk positions were determined with the Lumbar Motion Monitor (LMM). Six different models of stairchairs (Figure 1) were used in transporting a victim (weight: 70kg) down the flight of stairs and around a landing.

Upon arrival, each subject was instrumented with a LMM. Reflective markers were placed over the ankles, the lateral side of each knee, the greater trochanters, the acromium processes, the mid-line of the elbow, and the mid-point of the wrist breadth dimension. These points were used in quantifying body postures from the videotapes. Three different carrying positions (follower, the leader facing backward, and the leader facing

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forward) were investigated. Three tasks in each descent were analyzed: the initial entry onto the stairs, the mid-point down the stairs, and the negotiation of a 90? turn on a landing. Applied forces on the handles of the stairchairs were determined by mounting Chatillon force measurement gauges on the handles of each chair. Forces were determined for each position within each simulated task of each stairchair. The sequence of stairchairs and carrying positions was randomized for each subject. Each combination (stairchair and position) was repeated three times.

RESULTS AND DISCUSSION

Table 1 reports a summary of mean applied forces by position and task for all six stairchairs. As can be seen in Table 1, Model 6 recorded lower applied force values throughout all positions and tasks as compared to the other chairs. Additionally, the follower position experienced significantly higher loads as compared to the leader position.

Table 1: Summary of mean applied forces (Newton) by position, task and stairchair.

	Task 1: Initial		Task 2: Middle		Task 3: 90? Turn (Landing)	
Stairchair	**Follower**	**Leader**	**Follower**	**Leader**	**Follower**	**Leader**
Model 1	510 N	270 N	510 N	270 N	510 N	270 N
Model 2	458 N	314 N	458 N	314 N	458 N	314 N
Model 3	487 N	269 N	487 N	269 N	266 N	101 N
Model 4	440 N	338 N	440 N	338 N	440 N	338 N
Model 5	398 N	368 N	398 N	368 N	436 N	330 N
Model 6	7 N	78 N	40 N	59 N	17 N	0 N*

* Stairchair designed to be operated by the follower alone.

Figure 2 depicts the carrying postures and applied forces for the follower and leader facing forward positions. Table 2 reports the summary of mean postural angles of the body for each stairchair, position, and task. In terms of torso flexion, Model 3 was determined to elicit higher mean values as compared to all other chairs. Task 3 was determined to be associated with significantly higher values of torso flexion. Additionally, the follower recorded significantly lower torso flexion values than all other positions.

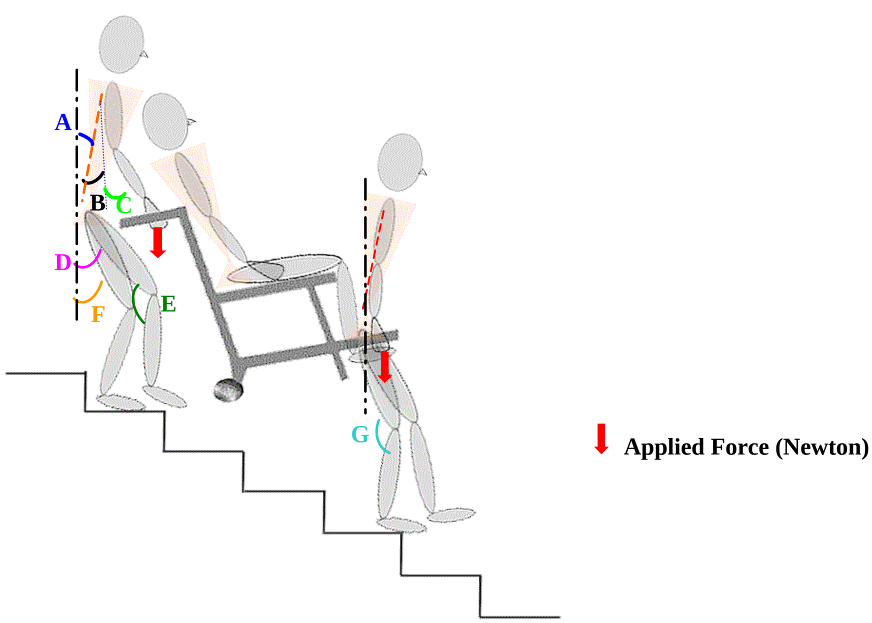

Figure 2: Carrying postures and applied forces for the follower and leader facing forward positions (Task 2: middle of stairs).

MODEL 1

MODEL 2

MODEL 3

MODEL 4

MODEL 5

MODEL 6

Figure 1: Six models of stairchairs used in this study

Table 2: Summary of mean postural angles for stairchair, position, and task (degrees).

Stairchair	Position	Task	(A) Torso Flexion	(B) Upper arm	(C) Forearm	(D) Left Upper Leg	(E) Left Lower Leg	(F) Right Upper Leg	(G) Right Lower Leg
Model 1	Follower	1	0	7	40	62	126	61	114
		2	-2	4	24	69	91	64	106
		3	-6	1	33	76	83	68	105
	Leader Bw	1	2	0	32	80	83	60	101
		2	1	1	27	71	104	71	108
		3	8	1	35	74	88	66	99
	Leader Fw	1	-2	1	27	71	104	71	108
		2	-2	0	7	76	87	77	88
		3	5	1	12	77	86	68	104
Model 2	Follower	1	2	23	45	60	124	61	120
		2	0	5	32	63	105	64	100
		3	-8	2	32	74	93	74	85
	Leader Bw	1	8	2	38	77	86	65	97
		2	1	1	42	70	95	70	95
		3	6	5	33	66	113	68	114
Model 3	Follower	1	10	12	44	55	128	55	132
		2	4	12	32	58	111	59	114
		3	-4	10	47	71	94	73	96
	Leader Bw	1	2	0	38	75	88	68	99
		2	3	0	29	74	92	62	96
		3	63	0	28	73	93	63	95
	Leader Fw	1	10	1	24	76	81	68	101
		2	1	0	26	78	85	73	84
		3	63	5	9	62	111	61	114
Model 4	Follower	1	-3	13	36	59	119	59	116
		2	-6	7	24	68	94	66	107
		3	-3	5	47	75	89	61	109
	Leader Bw	1	5	0	38	71	92	67	95
		2	1	1	43	72	91	65	97
		3	21	7	30	63	113	63	117
Model 5	Follower	1	-1	5	41	62	108	62	119
		2	-2	2	21	70	87	68	99
		3	-5	1	34	75	83	71	101
	Leader Bw	1	6	0	18	74	85	67	102
		2	2	0	20	73	95	66	96
		3	12	0	19	72	96	66	95
	Leader Fw	1	2	0	18	73	84	75	90
		2	-2	0	19	81	79	68	94
		3	1	2	16	72	90	71	99
Model 6	Follower	1	10	16	35	64	117	63	120
		2	8	11	26	68	95	66	112
		3	-6	36	78	79	78	72	98
	Leader Bw	1	5	7	48	78	83	70	87
		2	0	8	49	84	75	59	102
	Leader Fw	1	14	1	7	74	88	64	110
		2	0	0	10	76	92	72	91

Table 3 reports the means and standard deviations of the subjective ratings of perceived exertion (RPE) (Borg, 1970) for stairchair, position, and task. Duncan's Multiple Range test was performed on the means to determine the differences between mean values. The resulting homogenous subsets are indicated in the header (italic letters) of Table 3. As can be seen in Table 3, under the heading of stairchair, Model 6 had significantly lower RPE values compared to other stairchairs across all the treatment combinations. The follower position showed significantly higher RPE values than other positions while there were no significant differences between the leader facing forward and leader facing backwards positions. Finally, there was no significant difference between tasks in terms of subjective ratings.

Table 3: Summary of mean (std. dev.) RPE scales across treatment combinations.

	Task 1: Initial			**Task 2: Middle**			**Task 3: 90? Turn (Landing)**		
Position ? **Stairchair**	Follower (*B*)	Leader Facing Backward (*A*)	Leader Facing Forward (*A*)	Follower (*B*)	Leader Facing Backward (*A*)	Leader Facing Forward (*A*)	Follower (*B*)	Leader Facing Backward (*A*)	Leader Facing Forward (*A*)
Model 1 (*B,C*)	12.1 (2.1)	8.7 (1.3)	8.9 (1.2)	13.0 (1.8)	9.6 (1.3)	8.9 (1.1)	12.3 (3.0)	9.8 (1.3)	9.8 (1.8)
Model 2 (*E*)	13.8 (2.8)	11.3 (2.0)	*	13.9 (2.9)	11.6 (1.8)	*	12.4 (2.3)	11.9 (2.1)	*
Model 3 (*C,D*)	10.4 (1.3)	9.6 (1.2)	12.6 (2.5)	10.1 (1.0)	10.0 (1.1)	11.4 (3.1)	10.3 (1.8)	11.4 (1.2)	13.0 (2.7)
Model 4 (*D*)	11.8 (2.6)	10.1 (1.7)	*	11.5 (2.4)	11.6 (1.9)	*	11.3 (2.6)	11.0 (1.7)	*
Model 5 (*B*)	9.9 (2.4)	9.8 (1.7)	9.6 (1.9)	10.4 (1.8)	10.6 (1.8)	9.1 (2.2)	9.8 (2.1)	10.0 (1.4)	10.0 (2.4)
Model 6 (*A*)	6.8 (1.4)	7.0 (0.5)	7.5 (1.3)	6.8 (1.0)	6.4 (0.7)	6.9 (1.2)	6.3 (0.5)	**	**

* Stairchair not designed for operation in this position. ** Stairchair designed to be operated by follower alone.

CONCLUSIONS

Results of this paper indicate that the design of stairchairs, coupled with an individual's anthropometry, may significantly influence working postures and applied forces experienced during stairchair transport. Ratings of perceived exertion support the notion that stairchairs designed to have the stairwell support the weight of the victim are less demanding on paramedics. Future designs of stairchairs would be well served to pay particular attention to accommodating the user. Stairchairs designed to minimize awkward postures encountered during patient transport may be able to reduce the risk of injury to emergency rescue personnel.

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