3.5. Repetitive Multi-Task, Long-Duration (> 2 hrs)

3.5.1. Product Packaging II, Example 9

3.5.1.1. Job Description

Rolls of paper weighing 25 lbs each are pulled off a moving conveyor to work stations where they are wrapped and placed in boxes, as shown in Figure 25. Conveyor delivery allows the roll to slide to the wrapping area, but the roll must be manipulated as it is wrapped. After wrapping, the roll is lifted from the table and placed in a box. The box is closed, secured, and lifted to a pallet. The worker completes this operation once per minute for a continuous duration of 8 hours. The worker does not twist when lifting the rolls of paper. The first lift (from the table to the box) requires significant control at the destination. The second lift (from box to pallet) does not require significant control at the destination.

3.5.1.2. Job Analysis

Since the job consists of more than one task, the multi-task lifting analysis procedure should be used. Task 1 consists of lifting the roll of paper from the table and placing it into a cardboard box, and Task 2 consists of lifting the loaded box from the floor onto the pallet. No asymmetric lifting is involved in either task (i.e., A = 0). The following task variable data were measured and recorded on the job analysis worksheet (Figure 26).

Task 1:

1. At the origin of the lift, the horizontal distance (H) is 21 inches and the vertical distance (V) is 38 inches.

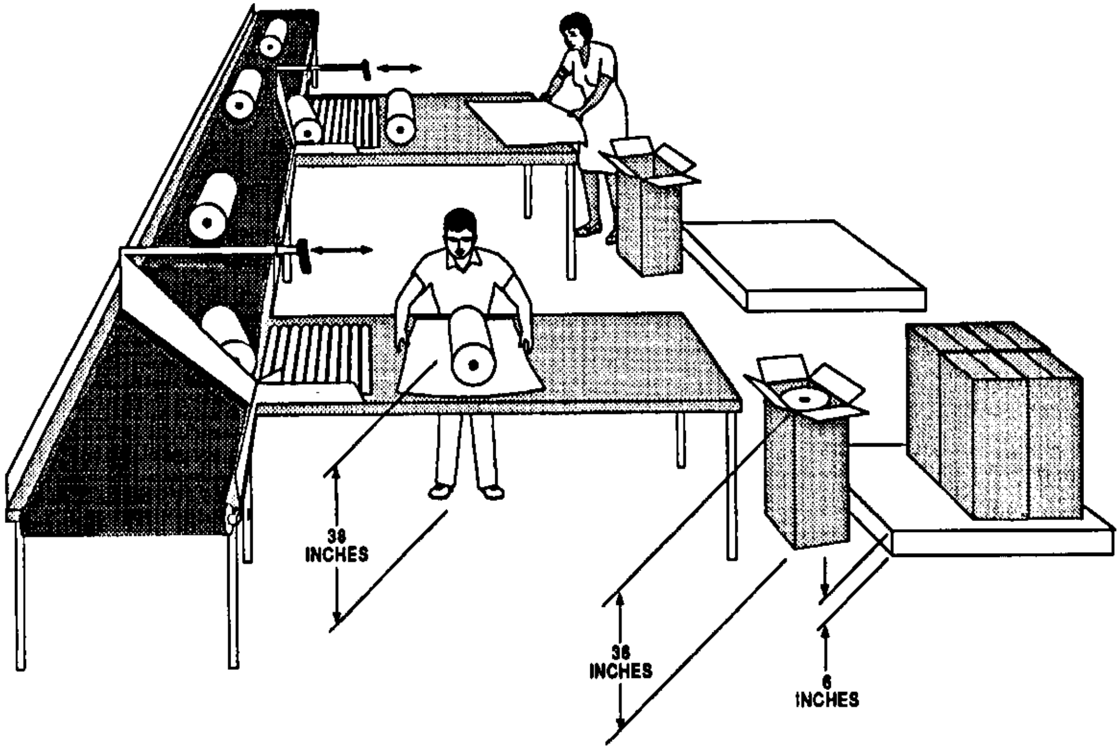

Figure 25 Product Packaging II, Example 9

MULTI-TASK JOB ANALYSIS WORKSHEET

DEPARTMENT Shipping

JOB TITLE Packager

ANALYST'S NAME

DATE

JOB DESCRIPTION
Wrapping and boxing products and lifting them to a pallet
Example 9, Product Packaging II

STEP 1. Measure and Record Task Variable Data

Task No.	Object Weight (lbs) L (Avg.)	Object Weight (lbs) L (Max.)	Hand Location (in) Origin H	Origin V	Dest. H	Dest. V	Vertical Distance (in) D	Asymmetry Angle (degs) Origin A	Dest. A	Frequency Rate lifts/min F	Duration Hrs	Coupling C
1	25	25	21	38	10	36	2	0	0	1	8	Poor
2	25	25	10	0	10	6	6	0	0	1	8	Fair

STEP 2. Compute multipliers and FIRWL, STRWL, FILI, and STLI for Each Task

Task No.	LC x	HM x	VM x	DM x	AM x	CM	FIRWL x	FM	STRWL	FILI = L/FIRWL	STLI = L/STRWL	New Task No.	F
1a	51	.48	.94	1.0	1.0	.90	20.7	.75	15.5	1.2	1.6	1	1
1b	51	1.0	.96	1.0	1.0	.90	44.1	.75	33.1	.6	.8	X	1
2	51	1.0	.78	1.0	1.0	.95	37.8	.75	28.4	.7	.9	2	1
	51												
	51												

STEP 3. Compute the Composite Lifting Index for the Job (After renumbering tasks)

	$STLI_1$ +	$\Delta FILI_2$ +	$\Delta FILI_3$ +	$\Delta FILI_4$ +	$\Delta FILI_5$	
CLI =		$FILI_2(1/FM_{1+2} - 1/FM_1)$	$FILI_3(1/FM_{1+2+3} - 1/FM_{1+2})$	$FILI_4(1/FM_{1+2+3+4} - 1/FM_{1+2+3})$	$FILI_5(1/FM_{1+2+3+4+5} - 1/FM_{1+2+3+4})$	
		.7(1/.65-1/.75)				
CLI =	1.6	.14				1.7

Figure 26: Example 9, JOB ANALYSIS WORKSHEET

2. At the destination of the lift, H is 10 inches and V is 36 inches.

3. If the rolls are handled lengthwise, as shown in Figure 25, then the couplings are classified as "poor", because the fingers can't be flexed near 90^0. (See Table 6).

Task 2:

1. At the origin of the lift, H is 10 inches and V is 0 inches.

2. At the destination of the lift, H is 10 inches and V is 6 inches.

3. The couplings are classified as "fair" because the fingers can be flexed under the box about 90^0 (See Table 6).

The lifting frequency rate for each task is 1 lift/minute. This means that two lifts occur each minute, since both Task 1 and Task 2 occur about once per minute.

The multi-task lifting analysis consists of the following three steps:

1. Compute the frequency-independent-RWL (FIRWL) and frequency-independent- lifting index (FILI) values for each task using a default FM of 1.0.

2. Compute the single-task-RWL (STRWL) and single-task-lifting index (STLI) for each task.

3. Renumber the tasks in increasing order of physical stress, as determined from the STLI value, starting with the task with the largest STLI.

Step 1

Compute the FIRWL and FILI values for each task using a default FM of 1.0. The other multipliers are computed from the lifting equation or determined from the multiplier tables (Table 1 to 5, and Table 7). Since Task 1 requires significant control at the destination, the FIRWL value must be calculated at both the origin (Task 1a) and the destination (Task 1b) of the lift.

	FIRWL	FILI
Task 1a	20.7 lbs	1.2
Task 1b	44.1 lbs	.6
Task 2	37.8 lbs	.7

The results indicate that these tasks should ***not require excessive strength.*** Remember, however, that these results do not take the frequency of lifting into consideration.

Step 2

Compute the STRWL and STLI values for each task, where the STRWL for a task is equivalent to the product of the FIRWL and the FM for that task. Based on the given frequencies, vertical heights, and durations, the FM values are determined from Table 5.

The results are displayed in Figure 26 and summarized below.

	STRWL	STLI
Task 1a	15.5 lbs	1.6
Task 1b	33.1 lbs	.8
Task 2	28.4 lbs	.9

These results indicate that, if performed individually, Task 2 would not be stressful, but that Task 1 ***would be stressful*** for some healthy workers. Note, however, that these values do not consider the combined effects of all of the tasks.

Step 3

Renumber the tasks, starting with the task with the largest STLI value, and ending with the task with the smallest STLI value. If more than one task has the same STLI value, assign the lower task number to the task with the highest frequency.

3.5.1.3. Hazard Assessment

Compute the composite-lifting index (CLI) using the renumbered tasks. Only the origin or destination component with the largest STLI is used to compute the CLI for the job when significant control is required for a task. As shown in Figure 26, the CLI for this job is 1.7, which indicates that this job ***would be physically stressful for some healthy workers.***

3.5.1.4. Redesign Suggestions

The worksheet illustrated in Figure 26 shows that the multipliers with the smallest magnitude (i.e., those providing the greatest penalties) for this task are .48 for the HM at the origin of Task 1, .78 for the VM for Task 2, and .90 for the CM at the origin and destination of Task 1. Using Table 8, the following job modifications are suggested:

1. Bring the load closer to the worker to increase HM by reducing the size of the roll and/or bringing the load between the worker's legs at the origin for Task 1.

2. Raise the vertical height of the lift for Task 2 at the origin and at the destination to increase VM.

3. Provide better couplings for Task 1 to increase CM

The largest penalty comes from lifting the rolls from the wrapping table into the box. A practical job redesign would be to provide a recess for the box at the end of the table, so that the worker could easily slide the roll into the box without lifting it. The worker could then slide the box to the edge of the table, and lift it from the table to the pallet. This job modification would allow the worker to get closer to the load when lifting, which would increase the FIRWL and decrease the FILI.

As an alternative job modification, the worker could be rotated from this job to a job with light work every one to two hours to decrease the lifting duration. This would provide a sufficient recovery period for the worker, so that fatigue would not become a problem. The light duty work, however, should last for at least .3 times the amount of time spent on the packaging job.

3.5.1.5. Comments

There is an inherent danger in trying to simplify a complex lifting job. The overriding concern is that the worker is not exposed to excessive biomechanical or physiological stress. This multi-task analysis procedure was designed to provide a series of intermediate values that would help guide the redesign of physically demanding lifting tasks. These values include the FIRWL, FILI, STRWL, and STLI. These intermediate values should not be used as design limits, since they only provide task specific information. The overall risk of injury for a lifting job is dependent upon the combined effects of the job, rather than the individual effects of the tasks.

3.5.2. Warehouse Order Filling, Example 10

3.5.2.1 Job Description

A worker lifts cartons of various sizes from supply shelves onto a cart as illustrated in Figure 27. There are three box sizes (i.e., A, B, and C) of various weights. These lifting tasks are typical in warehousing, shipping, and receiving activities in which loads of varying weights and sizes are lifted at different frequencies. Assume that the following observations were made: (1) control of the load is not required at the destination of any lift; (2) the worker does not twist when picking up and putting down the cartons; (3) the worker can get close to each carton; and, (4) walking and carrying are minimized by keeping the cart close to the shelves.

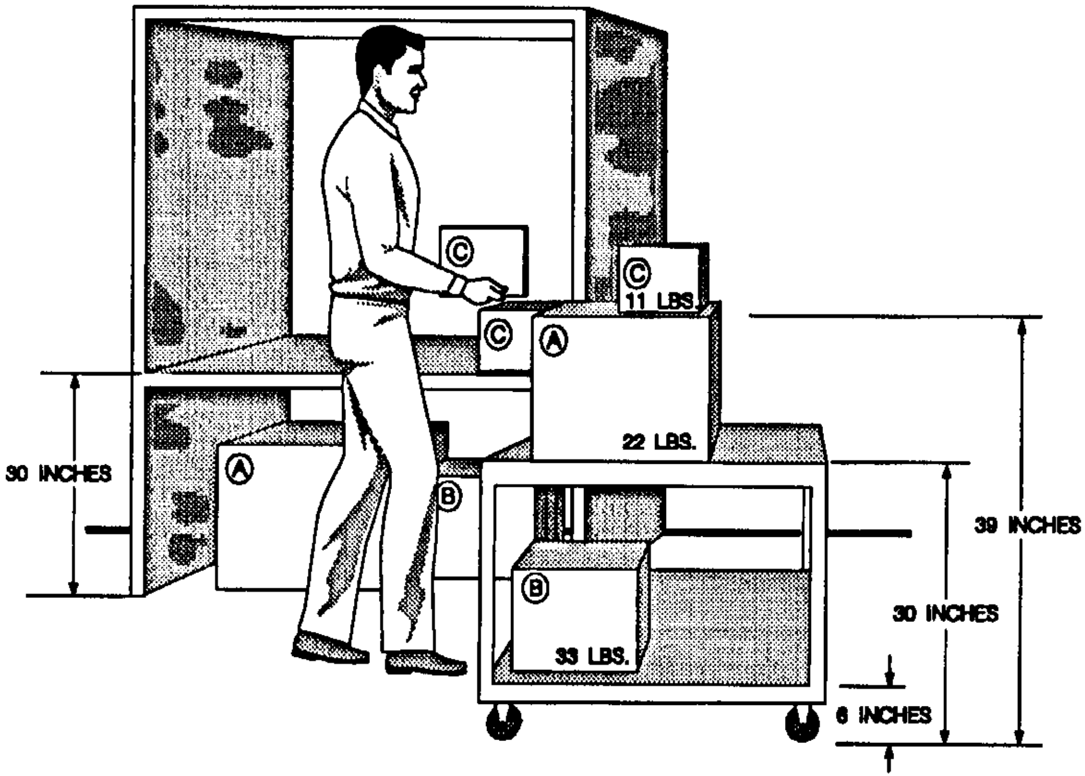

Figure 27 Warehouse Order Filling, Example 10

3.5.2.2. Job Analysis

Since the job consists of more than one distinct task and the task variables often change, the multi-task lifting analysis procedure should be used.

This job can be divided into three tasks represented by cartons A, B, and C. The following measurements were made and recorded on the job analysis worksheet (Figure 28):

1. The horizontal locations (H) for each task at the origin and destination are as follows: Box A, 16 inches; Box B, 12 inches; and, Box C, 8 inches.

2. The vertical locations (V) at the origin are taken to be the position of the hands under the cartons as follows: Box A, 0 inches; Box B, 0 inches; and, Box C, 30 inches.

3. The vertical locations (V) at the destination are the vertical position on the cart as follows: Box A, 30 inches; Box B, 6 inches; and, Box C, 39 inches.

4. The average weights lifted for each task are as follows: Box A, 22 lbs; Box B, 33 lbs; and, Box C, 11 lbs.

5. The maximum weights lifted for each task are as follows: Box A, 33 lbs; Box B, 44 lbs; and, Box C, 22 lbs.

6. No asymmetric lifting is involved (i.e., A = 0).

7. The lifting frequency rates for each task are as follows: Box A, 1 lift/min; Box B, 2 lifts/min; and Box C, 5 lifts/min.

8. The lifting duration for the job is 8 hours, however, the maximum weights are lifted infrequently (i.e., less than or equal to once every 5 minutes for 8 hours)

9. Using Table 6, the couplings are classified as fair.

MULTI-TASK JOB ANALYSIS WORKSHEET

DEPARTMENT Warehouse
JOB TITLE Shipping Clerk
ANALYST'S NAME
DATE

JOB DESCRIPTION
Selecting an order for shipment
Warehouse order filling
Example 10

STEP 1. Measure and Record Task Variable Data

Task No.	Object Weight (lbs) L (Avg.)	Object Weight (lbs) L (Max.)	Hand Location (in) Origin H	Hand Location (in) Origin V	Hand Location (in) Dest. H	Hand Location (in) Dest. V	Vertical Distance (in) D	Asymmetry Angle (degs) Origin A	Asymmetry Angle (degs) Dest. A	Frequency Rate lifts/min F	Duration Hrs	Coupling C
1 (A)	22	33	16	0	16	30	30	0	0	1	8	Fair
2 (B)	33	44	12	0	12	6	6	0	0	2	8	Fair
3 (C)	11	22	8	30	8	39	9	0	0	5	8	Fair

STEP 2. Compute multipliers and FIRWL, STRWL, FILI, and STLI for Each Task

Task No.	LC x	HM x	VM x	DM x	AM x	CM	FIRWL x	FM	STRWL	FILI = L/FIRWL	STLI = L/STRWL	New Task No.	F
1	51	.63	.78	.88	1.0	.95	21.0	.75	15.8	1.6	1.4	2	1
2	51	.83	.78	1.0	1.0	.95	31.4	.65	20.4	1.4	1.6	1	2
3	51	1.0	1.0	1.0	1.0	1.0	51.0	.35	17.8	.4	.6	3	5
	51												
	51												

STEP 3. Compute the Composite Lifting Index for the Job (After renumbering tasks)

CLI =	$STLI_1$ +	$\Delta FILI_2$ +	$\Delta FILI_3$ +	$\Delta FILI_4$ +	$\Delta FILI_5$	
		$FILI_2(1/FM_{1,2} - 1/FM_1)$	$FILI_3(1/FM_{1,2,3} - 1/FM_{1,2})$	$FILI_4(1/FM_{1,2,3,4} - 1/FM_{1,2,3})$	$FILI_5(1/FM_{1,2,3,4,5} - 1/FM_{1,2,3,4})$	
		1.6(1/.55-1/.65)	.4(1/.18-1/.55)			
CLI =	1.6	.45	1.5			3.6

Figure 26: Example 10, JOB ANALYSIS WORKSHEET

The multi-task lifting analysis consists of the following three steps:

1. Compute the frequency-independent-RWL (FIRWL) and frequency-independent- lifting index (FILI) values for each task using a default FM of 1.0.

2. Compute the single-task-RWL (STRWL) and single-task-lifting index (STLI) for each task.

3. Renumber the tasks in order of decreasing physical stress, as determined from the STLI value, starting with the task with the largest STLI.

Step 1

Compute the FIRWL and FILI values for each task using a default FM of 1.0. The other multipliers are computed from the lifting equation or determined from the multiplier tables (Table 1 to 5, and Table 7). Recall that the FILI is computed for each task by dividing the ***maximum*** weight of that task by its FIRWL.

	FIRWL	FILI
Task 1	21.0 lbs	1.6
Task 2	31.4 lbs	1.4
Task 3	51.0 lbs	.4

These results indicate that two of the tasks require strength demands that exceed the RWL level. Remember, however, that these results do not take the frequency of lifting into consideration.

Step 2

Compute the STRWL and STLI values for each task, where the STRWL for a task is equivalent to the product of the FIRWL and the FM for that task. Recall that the STLI is computed for each task by dividing the *average* weight of that task by its STRWL. The appropriate FM values are determined from Table 5.

	STRWL	STLI
Task 1	15.8 lbs	1.4
Task 2	20.4 lbs	1.6
Task 3	17.8 lbs	.6

These results indicate that Tasks 1 and 2 would be stressful for some workers, if performed individually. Note, however, that these values do not consider the combined effects of all of the tasks.

Step 3

Renumber the tasks, starting with the task with the largest STLI value, and ending with the task with the smallest STLI value. If more than one task has the same STLI value, assign the lower task number to the task with the highest frequency.

3.5.2.3. Hazard Assessment

Compute the composite-lifting index (CLI) using the renumbered tasks. As shown in Figure 28, the CLI for this job is 3.6, which indicates that this job would be physically stressful for nearly all workers. Analysis of the results suggests that the combined effects of the tasks are significantly more stressful than any individual task.

3.5.2.4. Redesign Suggestions

Developing a redesign strategy for a job depends on tangible and intangible factors that may be difficult to evaluate, including costs/benefits, feasibility, and practicality. No preferred procedure has been developed and tested. Therefore, the following suggestions represent only one approach to ergonomic job modification.

In this example, the magnitude of the FILI, STLI, and CLI values indicate that both strength and endurance would be a problem for many workers. Therefore, the redesign should attempt to decrease the physical demands by modifying the job layout and decrease the physiological demands by reducing the frequency rate or duration of continuous lifting. If the maximum weights were eliminated from the job, then the CLI would be significantly reduced, the job would be less stressful, and more workers could perform the job than before.

Those lifts with strength problems should be evaluated for specific engineering changes, such as (1) decreasing carton size or removing barriers to reduce the horizontal distance; (2) raising or lowering the origin of the lift; (3) reducing the vertical distance of the lift; improving carton couplings, and 4) decreasing the weight to be lifted. The redesign priority for this example is based on identifying interventions that provide the largest increase in the FIRWL for each task (Step 2 on worksheet). For example, the maximum weight lifted for carton A is unacceptable; however, if the carton at the origin were on the upper shelf, then the FIRWL for Task 1 would increase from 21.0 lbs to 27.0 lbs. The maximum weight lifted still exceeds the FIRWL, but lifts of average weight are now below the FIRWL. Additionally, providing handles, decreasing box size, or reducing the load to be lifted will decrease the stress of manual lifting.

3.5.2.5. Comments

This example demonstrates the complexity of analyzing multi-task lifting jobs. Errors resulting from averaging, and errors introduced by ignoring other factors (e.g., walking, carrying, holding, pushing and pulling activities, and environmental stressors), can only be resolved with detailed biomechanical, metabolic, cardiovascular, and psychophysical evaluations.

Several important application principles are illustrated in this example:

1. The horizontal distance (H) for Task 3 was less than the 10.0 inches minimum. Therefore, H was set equal to 10 inches (i.e., multipliers must be less than or equal to 1.0).

2. The vertical travel distance (D) in Task 2 was less than the 10 inches minimum. Therefore, D was set equal to 10 inches.