The Variable Lifting Index (VLI): A New Method for Evaluating Variable Lifting Tasks Using the Revised NIOSH Lifting Equation

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This paper describes the concept behind the Variable Lifting Index (VLI), a new approach for analyzing the physical demands of highly variable lifting tasks using the Revised NIOSH Lifting Equation formulas. The VLI procedures involve collecting lifting equation data on a subset of the lifting tasks to be analyzed. The Frequency Independent Lifting Index (FILI) is calculated for each of the tasks selected for analysis and then the each lift is fitted into six to nine FILI categories. The average values for each FILI category and the corresponding frequency of lifts in each category are then used as input into the Composite Lifting Index (CLI) equation previously published by NIOSH. This paper only focuses on the concept for the VLI equation. A simplified process for obtaining the data from the worksite is described in another paper (Colombini et al., 2009).

INTRODUCTION

Manual lifting jobs in industry can be defined according to the characteristics of the job. Some lifting jobs consist of a single lifting task in which the task variables do not significantly vary from lift to lift, or only one lift is of interest (e.g., worst case analysis). An example of a single-task lifting job would be a task such as lifting a patient or performing a single heavy lift once per day. Other lifting jobs may require a small set of repetitive unique lifting tasks (less than 10) that may be done concurrently, such as a palletizing job, where the vertical height can vary from lift to lift. These types of lifting jobs are defined as multi-task manual lifting jobs. Another example of a multi-task lifting job would be an assembly job where multiple items are picked up, assembled, and then lifted/lowered as a unit into a bin or rack for later delivery to the manufacturing line. A third type of lifting job is defined as a sequential lifting job where a worker may rotate between different specific workstation for a fixed period of time (either single or multi-task), and then transfer or rotate to another workstation to perform a different series of specified lifting tasks (either single- or multi-task). Each rotation position may have its own set of unique single or multi-task lifting tasks. Finally, a job may be defined as a variable-task manual lifting job where all of the lifts are highly variable, such as may be found in warehousing, baggage handling, and certain service jobs. In variable-task manual lifting jobs, the weight of the load being lifted and the geometry of the lift (e.g., horizontal reach, vertical height, etc.) may vary between each lift. These latter types of jobs are the most difficult to analyze from an ergonomics perspective.

NIOSH teams developed the lifting index (LI) equation for assessing single-task manual lifting jobs (Waters et al., 1993; Waters et al., 1994), the Composite Lifting Index (CLI) for assessing multi-task manual lifting jobs (Waters et al., 1993; Waters et al., 1994), and the sequential lifting index equation (SLI) for assessing sequential manual lifting jobs (Waters et al., 1997). To date, however, no NIOSH team has developed a method for assessing variable-task manual lifting jobs. The purpose of this paper is to present a new method for assessing the physical demands of jobs with variable manual lifting tasks. The new method is defined as the Variable Lifting Index, or VLI.

VARIABLE LIFTING INDEX (VLI) METHOD

The VLI, which is equivalent to the LI, CLI, or SLI for single-, multi-, or sequential-lifting jobs, will be computed using "probability data" collected at the worksite as input into the VLI equation. The input data for the VLI calculation will be obtained at the worksite through adjustable sampling methods, use of computerized production data obtained from the employer, when available, or some combination of the two sources of data. The sampling methods will be adjusted based upon the amount of variability observed in the task characteristics, such as the weight of load lifted, horizontal distance, asymmetry, etc. The greater the variability between lifts, the greater will be the requirement for data sampling.

The concept for the method is similar to the CLI method for multi-task jobs. The difference is that rather than using individual task elements, all of the lifts will be distributed into six LI categories, each with a variable frequency. These six LI categories will then be weighted using the CLI equation. The frequency multiplier for each category is based on the average overall frequency for the six individual LI categories. The VLI should provide a reasonable estimate of the physical demand of the job that can be used to determine if the task is acceptable or not and how changes in the mix of tasks might affect the overall physical demand of the job. The steps are as follows:

1. Determine the range of FILI values for all of the sampled lifts.
2. Divide the range of FILI values into six categories, taking into account the variability of obtained results.
3. Determine the frequency of lifts in each of the six categories.
4. Apply the VLI using the CLI equation, but use the frequency data for each LI category to calculate the appropriate FM values for the calculation.

The VLI is computed as follows:

1. The task categories are renumbered in order of decreasing physical stress, beginning with the task category with the greatest STLI down to the task category with the smallest STLI. The task categories are renumbered in this way so that the more difficult task categories are considered first.

2. The VLI for the job is then computed according to the following formula:

$$VLI = STLI_1 + \sum \Delta LI$$

Where:

$$\sum \Delta LI = (FILI_2 \; X \; (\frac{1}{FM_{1,2}} - \frac{1}{FM_1}))$$

$$+ (FILI_3 \; X \; (\frac{1}{FM_{1,2,3}} - \frac{1}{FM_{1,2}}))$$

$$+ (FILI_4 \; X \; (\frac{1}{FM_{1,2,3,4}} - \frac{1}{FM_{1,2,3}}))$$

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$$+ (FILI_n \; X \; (\frac{1}{FM_{1,2,3,4,\dots,n}} - \frac{1}{FM_{1,2,3,\dots,(n-1)}}))$$

Note, that (1) the numbers in the subscripts refer to the new task category numbers; and, (2) the FM values are determined from the frequency table published in the Applications Manual (Waters et al., 1994). The appropriate FM values are based on the sum of the frequencies for the task categories listed in the subscripts.

Example

A hypothetical example will demonstrate how the VLI equation might be applied. Assume that job sampling at a manufacturing plant revealed that the largest FILI sampled for any individual lift was 2.8. According to the VLI procedure, the six LI categories would be defined as: 0-.45, .46-.61, .62-.99, 1.0-1.51, 1.52-2.02, and 2.03-2.8. Also, assume that analysis of the sampled data revealed that the average FILI for individual lifts in each of these six categories and the percentage of tasks falling into the six cells are shown in Table 1. If the overall frequency of lifting across an eight-hour shift is 4/min, then the frequency of lifts for each category can be calculated (see Table 1).

Table 1. Hypothetical data for VLI example

	LI Categories					
Category Data	0-.45	.46-.61	.62-.99	1.0-1.51	1.52-2.02	2.03-2.8
Representative FILI within category	0.33	0.53	0.79	1.20	1.66	2.8
Renumbered	6	5	4	3	2	1
Percentage of Tasks	10%	15%	25%	25%	15%	10%
Frequency (lifts/min)	0.5	0.9	1.1	0.9	0.4	0.2

Based on the hypothetical data presented, the VLI for this job can be calculated, as follows:

$$VLI = STLI_1 + \sum \Delta LI$$

$STLI_1 = 3.32$

$\Delta FILI_2 = 1.66 ((1/.80) - (1/.85)) = .116$

$\Delta FILI_3 = 1.2 ((1/.70) - (1/.80)) = .204$

$\Delta FILI_4 = .79 ((1/.60) - (1/.70)) = .205$

$\Delta FILI_5 = .53 ((1/.50) - (1/.60)) = .159$

$\Delta FILI_6 = .33 ((1/.46) - (1/.50)) = .069$

$VLI = STLI_1 + \Delta FILI_2 + \Delta FILI_3 + \Delta FILI_4 + \Delta FILI_5 + \Delta FILI_6$

$= 3.32 + .116 + .204 + .205 + .159 + .069 = 4.07$

SUMMARY

The VLI method should provide a useful method for assessing lifting tasks with highly variable task characteristics. The method remains to be validated.

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