Procedures for collecting and organizing data useful for the analysis of variable lifting tasks and for computing the VLI.

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This work presents, from a practical and applicative point of view, the procedures for evaluating several manual lifting (sub)tasks including the "variable tasks" and for calculating the corresponding VLI (variable lifting index), maintaining the original NIOSH criteria, via simplifications in data collection and a new dedicated software. This revised procedure is not "mandatory" but could be considered as a guideline to all potential users on how to adequately collect and manipulate relevant data to produce the final output. In this revised procedure, it is suggested to describe all the loads handled by a worker in a shift and to group them into 5 "weight categories". For each of them the relevant aspects of "lifting geometry" are also described: vertical origin/destination (simplified in 2 possibilities); horizontal distance (simplified in 3 possibilities); asymmetry (simplified in only 1 possibility : present or not). For each lifting geometry, within each weight category, the lifting frequency will be estimated. This procedure generates up to (and no more than) 30 variables (or subtasks) (5 loads x 2 vertical geometries x 3 horizontal geometries).
At the end it will be possible to compute individual FILI (for up to 30 subtasks). Since up to 30 FILI (for corresponding subtasks) are still too many, it is suggested to proceed to a further "aggregation", by grouping the 30 possible FILI into up to 6 "FILI Categories" and compute the cumulative frequency for each FILI category. After this aggregation one can proceed to compute the VLI using the "traditional" CLI (composite lifting index) approach.

INTRODUCTION

The concept of Variable Lifting Index (VLI), a new method for assessing the physical demands of jobs with variable manual lifting tasks, is presented in a separate paper at this conference (Waters et al., 2009).

When studying a manual lifting task the following task characteristics and definitions could be found from an operative point of view:

- MONO TASK (defined as single-task by NIOSH) are defined as tasks involving the lifting of only one (kind of) object (with the same load) using always the same posture (body geometry) between origin and destination . In this case the "traditional" Lifting Index (LI) computational procedure could be followed (Waters et al., 1993).
- COMPOSITE TASK (defined as multi-task by NIOSH) are defined as tasks involving lifting objects using different geometries (collecting and positioning from/on shelves placed at several heights and/or depth levels) and possibly different laid weights. Practically each individual geometry takes the name of "subtask". In this case the Composite Lifting Index (CLI) computational procedure could be followed (Waters et al., 1994). It has been postulated that no more than 10-12 subtasks could be considered by this procedure.
- SEQUENTIAL TASK is defined as a job in which the worker rotates between a series of single or multiple task lifting rotation slots during a work shift. In this case the Sequential Lifting Index (SLI) computational procedure could be followed (Waters et al., 2007).
- VARIABLE TASK is defined as a job in which the geometry and load weight may vary for every lift performed by the worker. The VLI is suggested for assessing these types of jobs (Waters et al., 2009)

This paper presents from a practical and applicative point of view, a simplified procedure for evaluating conditions where several manual lifting subtasks (variable task) are performed and for calculating the corresponding VLI (variable lifting index), maintaining the original NIOSH criteria, via simplification in data collection and a new dedicated software.

GENERAL OUTLINE OF THE PROCEDURE

The VLI 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 production data obtained from the employer, when available, or some other method. The sampling methods will be adjusted based upon the amount of variability observed in the task characteristics, such as the weight of load lifted, vertical location, horizontal distance, asymmetry, etc. The greater the variability between lifts, the greater will be the requirement for data sampling.

The key-elements of the procedure are the following:

- Whichever the number of potential individual tasks, compress them into a structure that considers up to a maximum of 30 subtasks for different loads (weight categories) and geometries using the following approach:
    - Up to 5 objects (weights) categories .
    - Classification of vertical location (VM) in only 2 categories (good/bad).
    - Classification of horizontal location (HM) in up to 3 categories (near; medium; far).
- Presence of asymmetry could be generally assessed for each of 5 load categories (present or absent by threshold value).
- Daily duration of lifting classified as usual.
- Frequencies of lifting action attributed or specifically determined for each of the (up to 30) considered subtasks.
- Vertical displacement and coupling are both considered as a constant.
- At the end it will be possible to compute individual LI for up to 30 subtasks.
- Since up to 30 LI values (for corresponding subtasks) exceed the NIOSH recommendation for using the CLI (especially considering individual frequencies), we proceed to another "aggregation", grouping the 30 possible LI into 1 to 9 "LI Categories" (according to their variability) and compute the cumulative frequency for each of those individual LI categories.
- After this aggregation, it is possible to compute the VLI using the "traditional" Composite Lifting Index (CLI) approach (Waters et al, 1994).

Dedicated software is helpful in performing these computations.

PROCEDURE DETAILS

Collecting organizational and production data

The study of organizational data is preliminary for all types of tasks: mono, composite, variable or sequential.

The first assessment step is identifying the worker/s and their number (1or more) involved in homogeneous manual handling activities.

Then the manual lifting task/s and their respective duration has to be assessed in the shift also considering the real sequence of lifting activities as alternated with other “non manual handling” activities and/or interrupted by “breaks”.

The weight (from 3 Kg. up to maximum , by incremental steps of 1 Kg.) and relative number of objects lifted manually in a shift by the worker (if one) or by the whole homogeneous group of workers is then indicated.

The persons in charge of the organization generally have production data that can be used to assist in obtaining this information. The knowledge of object weight is actually mandatory in some country and should be provided on the packing**.** Please note that if some objects are lifted several times between origin and destination, the number of times each object is actually displaced is to be indicated, and this will change the number of objects actually lifted.

The indicated weights should be aggregated (by a dedicated software) into a maximum of 5 weight categories, on a statistical basis, varying according to respective type and quantity.

From previous data such as “number of workers involved in the task(s)”, “net duration of manual lifting in the shift”, “total number of objects lifted during a shift”, “number of objects within each weight category lifted during a shift”, the analyst can determine the overall lifting frequency (per worker) and the lifting frequency for each weight category (maximum 5). One can consequently choose and use the appropriate Frequency Multipliers (FM) from traditional tables (Waters et al., 1993) considering the appropriate lifting duration scenario (short; moderate; long).

Simplification of variables.

In order to compute one or more LI for each weight category previously determined, simplifications in different variables (and relative multipliers) of the original Lifting Equation (Waters et al., 1993) could be adopted.

Suggested guidelines for these simplifications that consider the different variables in the equation are given below.

Vertical location (height of hands at lifting origin).

The variable “height of hands at lifting origin/destination” was reduced to 2 areas:

- IDEAL AREA. Hands are within 50 and 125 cm.; the vertical multiplier (VM) is equal to 1.
- NON IDEAL AREAS. Hands are below 50 cm. or above 125 cm (up to 175 cm.).; the vertical multiplier (VM) is equal to 0.78.

According to this option one could compute 2 subtasks for each weight category (up to 10 subtasks so far).

Extreme areas (>175 cm) are considered as an additional option, completely inadequate (no computation is possible) and to be avoided.

Horizontal location (maximum hand grasp point away from the body during lifting).

The horizontal distances were simplified in 3 areas:

- IDEAL AREA (near). Horizontal distance is within 25-40 cm.; the representative horizontal multiplier (HM) is equal to 0.71 (for a representative value of 35 cm.)
- NON IDEAL AREAS (medium). Horizontal distance is within 40-50 cm.; the representative horizontal multiplier (HM) is equal to 0.56 (for a representative value of 45 cm.)
- NON IDEAL AREAS (far). Horizontal distance is within 50-63 cm.; the representative horizontal multiplier (HM) is equal to 0.40 (for a representative value of 63 cm.)

According to this option, one could compute 3 subtasks for each weight category (up to 30 subtasks so far).

Extreme areas (>63 cm) are considered as an additional option, completely inadequate (no computation is possible) and to be avoided.

Asymmetry (angular displacement of loads).

Trunk rotations are considered synthetically for each “weight category”. An asymmetric multiplier (AM) of 0.81 is assigned to all the subtasks in the category if trunk rotations exceed 45° and are present (in that category) for over 50% of lifting actions. Otherwise asymmetric multiplier is equal to 1.

Vertical travel distance (vertical distance between the height of hands at origin and at destination).

Assessment of this factor was skipped. The corresponding multiplier (DM) is considered as a constant to be equal to 1. It is to be underlined that when assessing vertical location (VM), one should consider height of hands both at lifting origin or at destination.

Type of grip (coupling).

Assessment of this factor was skipped. Since, based on experience, “good grips” are quite rare, the corresponding multiplier (CM) is considered as a constant to be equal to 0.90.

Aggregation of resulting LI (Lifting index) and computation of final Variable Lifting Index (VLI).

By adopting the illustrated procedures, one can analyse a “variable lifting task” scenario and produce up to 30 Lifting Index (LI), by using the traditional Lifting Equation, for 30 different subtasks (5 weight categories *x* 2 Vertical Location *x* 3 Horizontal Areas *x* 1 Asymmetry condition). For each of those subtasks as well as for the overall “variable” task, frequency of lifting is also estimated.

30 LI (for corresponding subtasks) are always too many (especially considering individual frequency of lifting) for correctly applying the "traditional" Composite Lifting Index (CLI) approach (Waters et al, 1994). So, except in cases when no more than 10 “subtasks” (and corresponding LI) are generated, it is suggested to proceed to another "aggregation", grouping up to 30 possible LI into 6 "LI categories".

In particular, in order to generate those 6 LI categories, the FILI (Frequency Independent Lifting Index) is computed for each of the possible 30 “subtasks”, previously determined.

Among those FILI values, the 10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} percentiles values are determined: those “key” percentiles, taking into account the variability of obtained results, determine the limits for aggregating the “subtasks” into 6 "LI categories". Consequently the cumulative frequency of lifting for each of those 6 LI categories is also considered.

It is now possible to compute, for each one of those new 6 "LI categories", their respective FILI (single task lifting index independent from frequency) and STLI (single task lifting index considering frequency).

Finally, using those data, the Variable Lifting Index (VLI) is computed using the traditional CLI approach and equation (Waters et al, 1994).

DISCUSSION AND RECOMMENDATIONS

The NIOSH lifting index method (also with some “variants”) is widely adopted in many national and international guidelines as well as in International Standards (i.e. EN 1005-2 and ISO 11228-1).

Our experience using the LI, CLI, and SLI methods has led us to recognize that a different method is needed because variable lifting tasks are often found and these methods do not work with variable tasks.

In trying to use the CLI we attempted to analyze several different tasks for the same job, but we encountered problems in data collection and computing a CLI value (especially with regard to the frequencies).

The proposed simplified method comes from our experiences and is an attempt to have a relatively simple (especially if assisted by a dedicated software) risk estimation model when many highly variable lifting tasks are performed during a daily period. The proposed method is in-line with and may improve upon international standards on manual lifting (i.e. ISO 11228-1 and EN 1005-2).

The proposed method, with its simplifications, has been used and tested by authors in about 50 real working contexts. In the same contexts the full model (based on CLI approach) was also applied. In both cases the use of dedicated software facilitated application of the procedure. The preliminary results show good “agreement” using the 2 approaches and little or no risk misclassification. A full validation of the proposed procedure is however needed.

Despite this, the procedure allows, at field level, a risk analysis for consequent prevention and management purposes that could be useful to potential users. It is also responsive to requests from international standards bodies to update the methods for assessing manual lifting.

Dedicated software has been developed and will be made available free of charge to all requestors.

Reactions (and proposals of improvements) when using the procedure and the software will be highly welcome.

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