OCCUPATIONAL HEALTH

SPECIAL INTEREST GROUP

PRESIDENT'S MESSAGE

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Rick Wickstrom PT, DPT, CPE, CDMS submitted this summary of the latest activity to replace the Dictionary of Occupational Titles.

In July 2012, SSA signed an interagency agreement with the Bureau of Labor Statistics (BLS) to test occupational data collection methods that could lead to the development of a new Occupational Information System (OIS). The new OIS will replace the outdated Dictionary of Occupational Titles (DOT) in our disability determination process. In fiscal year 2013, BLS began testing the feasibility of using the National Compensation Survey (NCS) platform as a means to gather the occupational data needed by SSA for the OIS.

The Occupational Requirements Survey (ORS) is under development by the Bureau of Labor Statistics' (BLS) National Compensation Survey (NCS) program in association with the Social Security Administration (SSA). The ORS seeks to provide job characteristics data to help the SSA in their disability determination process. Specifically, the ORS will gather job-related information regarding physical demands, environmental conditions, and vocational preparation requirements.

The NCS recently completed Phase 1 of the ORS tests conducted in cooperation with the SSA. The main objective of the 3 ORS tests in fiscal year 2013 is to assess whether it is feasible for BLS to collect data relevant to the SSA's disability program using the NCS platform. The results of the Phase 1 proof-of-concept test suggest that this approach is viable. Respondents agreed to participate in the test; BLS field economists were able to capture the required data from traditional NCS respondents, and individual data element response rates were very high. The full report may be accessed at: http://www.ssa.gov/disabilityresearch/documents/Phase%20I%20Report%20Final.pdf.

I made a follow-up request and obtained information from the tech memo that describes the survey factors and scaling. No changes were made to the load ranges for the strength factor. The survey separated out the posture tolerances and established separate scales for occasional, frequent, and constant. There was no guidance on repetitions for each level of frequency. This is a quick survey approach, 10 to 12 minutes, rather than actual observation via a functional job analysis.

For more information on the latest activities related to SSA's development of a new occupational system, Go to: http://www.ssa.gov/disabilityresearch/occupational_info_systems.html

Common Industrial Ergonomics Assessment Tools for Physical Therapists

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The term ergonomics or as it is often termed, human factors, is commonly defined as the process of fitting the workplace to the worker.[1] A more precise description of human factors/ergonomics by Chapanis is that it "discovers and applies information about human behavior, abilities, limitations, and other characteristics to the design of tools, machines, systems, tasks, jobs, and the environments for productive, safe, comfortable, and effective human use."[2] From toothbrush handles to airline cockpits, ergonomics principles are used to create user-friendly and safe interactions between a human and their environment. The field of ergonomics has historically been more the domain of the engineering and psychology professions than that of health care. However, with the growing emphasis on employer health care costs, more and more companies are beginning to use the unique skills and knowledge of physical therapists to provide ergonomic assessments in the work environment.[3-5] Whether it be assembly line layouts, tool selection or station designs, physical therapists may provide analyses of the work environment from the biomechanical and pathophysiological perspective that can assist engineers and safety personnel in the design or modification of equipment to reduce the likelihood or work-related musculoskeletal disorders.

Physical therapists that work in the occupational health environment have extensive knowledge of anatomy, biomechanics, and common risk factors for work-related injuries. These skills, while a good foundation for a clinician in the industrial setting, do not by themselves constitute proficiency in ergonomics assessment. Knowledge of the standard assessment tools within the ergonomics field is imperative for the physical therapist if he or she wishes to operate within this area. These tools, which range from simple checklists to sophisticated mathematical models, vary in their application and use.[6] Some are easy to learn and can be executed by people without much experience in work analyses while others require extensive data collection and software and may be more suitable to devoted ergonomics professionals. Most of the commonly used tools, however, are easily accessible online for free.[7,8]

Some of the tools for ergonomic assessment have significant, direct evidence to support them, although many do not. Most have few peer-reviewed studies supporting their construct validity. Many rely instead on biomechanical models or other indirect rationale for purporting their effectiveness. Ergonomic assessment tools also vary widely in the type of the data upon which they are derived. Some use objective variables such as lift heights, pull forces, and object weights, while others use subjective information like perceived difficulty ratings.[9,10] Some tools assess the worker's entire body or general metabolic demands. Others assess the risk for only one body part such as the hand and wrist or the lumbar spine. One ergonomics assessment tool for the lumbar spine is the Revised NIOSH Lifting Equation (RNLE). In 1981, in response to a growing number of lumbar injuries during the second half of the 20th century, the National Institute for Occupational Safety and Health (NIOSH) published the Work Practices Guide for Manual Lifting.[11] This guide summarized the current published research at that time about lifting. In addition, the guide offered a mathematical model for calculating the risk of lumbar injury from lifting activities. This mathematical model was updated in 1991 as the RNLE.[12] The RNLE enabled a more effective assessment of scenarios involving asymmetrical lifting and lifting objects with variable "quality of hand-to-object coupling." In addition, the revised equation provided a method to assess the impact on the worker of lifting tasks with variable durations and frequencies.[13] Originally, the RNLE was released as a booklet and was generally calculated by hand, though now it can be found on the internet and is easily executed using the various online NIOSH calculators.[14]

The theoretical basis behind the development of the RNLE rests on the consideration of lumbar injury epidemiology and the biomechanical, physiological, and psychophysical limitations of the worker.[15] The biomechanical model maintains that increased compressive and tensile loads of the lumbar region will result in structural damage of the spine. Various mathematical models have been used to formulate a theoretical compressive load on the L5-S1 intraspinal disc. Compressive forces that exceed threshold limits of 3400 N are purported to correlate with an increased risk of lumbar injuries, primarily that of end-plate fractures at the L5 and S1 vertebrae.[16] The physiological approach of assessing low back pain risk takes into consideration the energy expenditure and fatigue that is associated with material handling. Physiological research was used to help formulate acceptable limits for the metabolic requirements of repetitive lifting. The psychophysical model of lumbar pain takes into consideration the individual's perception of an acceptable amount of exertion and assumes that the worker is able to estimate his or her own maximum acceptable weight that can be handled.[12] All 3 of these paradigms contribute to the formation of the RNLE, in theory enabling the tool to capture the different physical and psychosocial aspects of the material handling environment during its use.

The Revised NIOSH Lifting Equation attempts to quantify the risk of a single lifting task or multiple lifting tasks for the majority of healthy adults. The tool is not meant to assess the lifting capabilities of individuals with underlying medical conditions that would predispose them to back injuries or those who have previous histories of lumbar disorders. The equation is based on a comparison between the actual weight that is lifted, the load constant (LC), versus a theoretical safe weight, the recommended weight limit (RWL), during a given material handling scenario. The RWL must be calculated by multiplying the LC by 6 different task multipliers. The task multipliers are found by taking the horizontal distance of the lift from the midline of the body, the frequency of lifting, the quality of hand coupling of the lift, the distance that the lifted object travels in the vertical plane, and the total time spent on the job per day and cross-referencing them in the NIOSH lifting equation tables to find each task's variable multiplier. Table 1 lists the "measureable task descriptors" that must be assessed for the lifting activity.

Task multipliers are provided by NIOSH in tabular form and will be a number between zero and one. The more the task variable deviates from an ideal lifting position, the smaller the task multiplier becomes. A task multiplier of 1.0 would have no ergonomic impact on the assessment while a task with a multiplier of 0.5 would reduce the RWL by 50%, etc. For example, if a task requires one to lift an object from 24" away from the body, then the horizontal modifier assigned to this lift from the NIOSH tables would be 0.42. This means that the horizontal distance of the lift from the worker would be so great that only 42% of the load constant, or 21.4 lbs, would be considered safe for most of the population.

Therefore, each of the 6 task multipliers can reduce the RWL depending on the position, frequency, coupling, or duration of a given task. The RWL is the product of all six multipliers and the LC. The LC is set by NIOSH at 51 lbs. This means that under ideal conditions the maximum amount of weight that can be lifted by the majority of the healthy working population is 51 lbs. Anything in excess of this number is thought to exceed the safe lifting capabilities of at least part of the population. Any deviation from ideal lifting conditions then reduces this theoretical weight limit.

RWL = HM x DM x AM x CM x FM x VM x LC (51 lbs)

The actual weight lifted during the assessed task is divided by the RWL to create a ratio, the lifting index (LI), for an activity. The LI is the final output of the equation, allowing the consumer to rate the relative risk for lumbar injury with a numerical value. Lifting indices below 1.0 are thought to be relatively safe for most of the working population. As LIs exceed 1.0, the risk for lumbar injuries increases. While exact cut-offs for what is safe or unsafe is equivocal within the ergonomics world, most agree that as the LI exceeds 1.0 and approaches 3.0 there exists significant risk for most of the population.[17]

Lifting Index = (Actual Weight Lifted)/(Recommended Weight Limit)

The LI can be used to rank different activities within the same facility, for example, or used as a mechanism to aid in the design or alteration of equipment and material handling tasks. When designing an assembly line station or setting the maximum allowable carrying capacity of a bin for example, the equation can be used in reverse with the LI set to 1.0 or lower to establish an acceptable dimension of design, such as the horizontal distance.

When there are multiple lifting tasks that vary from one another significantly within the same job, an alternate version of the equation that uses the cumulative lifting index (CLI) should be used. The CLI replaces the LI for jobs with multiple lifting tasks. One may be tempted to use average weights, heights, and frequencies of multiple, disparate lifting activities to create a mean RWL. Unfortunately, this can yield an erroneous LI. For instance, if a 20" and a 40" vertical lift were averaged together the result would be 30" which is considered optimal by the single-lift equation. In fact both the 20" and the 40" lift, both deviate significantly from the ideal lift height of 30". The CLI calculation then can be used to appropriately combine the relative risk of separate lifts without underestimating the LI. It requires that each lift be assessed with the same variables that were listed for the single-lift equation in Table 1 except for the frequency modifier. In the multi-lift equation, the frequency of each lift assumes its own modifier, separate from that of the other lifts. For instance, if Worker A lifts a widget once per minute and a gidget twice per minute, then the frequency of the widget lift would be 0.94 and the frequency multiplier of the gidget lift would be 0.91. The equation then uses the LI for each lift separately and then adjusts them using the frequency modifiers to create a cumulative lifting index (Table 2.) The complexity of this formula can be daunting if the CLI is calculated by hand. Fortunately, numerous Web sites exist that offer free analysis software or excel documents that make the equation as simple as entering in the variables.

Table 1. Revised NIOSH Lifting Equation Descriptions

- Horizontal Location (H) – The horizontal distance between a point midway between the hands at the time of the lift, to a point midline between the ankles at the time of the lift. Measured in inches.
- Vertical Travel Distance (D) – The vertical distance travelled during the lift. Measured in inches.
- Asymmetry Angle (A) – The angular distance, in degrees, between the intermalleolar line and the line between the hands. Measured in degrees.
- Coupling Classification – A descriptive designation of "Good," "Fair," or "Poor."
- Vertical Location (V) – The vertical height of the beginning of the lift. The NIOSH lifting equation sets 30 inches as the optimal height for lifting. As lifting distances deviate from this height more and more it result in a progressively smaller multiplier. Measured in inches.
- Lifting Frequency (F) – The number of lifts per a given time period. The FM is also adjusted for the total duration that the worker spends at the station up to 8 hours in a shift.

Several studies have examined the validity of the RNLE. In an expanded cross sectional analysis performed by Waters et al,[18] the authors concluded that as the LI increases, the prevalence of low back pain increases as well. Wang et al and Boda et al also found a correlation between the LI and complaints of low back pain in industrial workers.[19-21] A study by Marras et al[22] showed that the revised equation to be more sensitive than the 1981 NIOSH guide in identifying high risk jobs.[22] They also concluded that the revised equation was less specific than the 1981 guide as it did a much poorer job identifying low risk jobs. The authors discussed the possibility that the revised NIOSH lifting equation may be too conservative when predicting higher-risk activities. This sentiment was also alluded to in a study by Elfeituri et al.[23] These authors noted a significant difference between the RWL and the maximum acceptable weight of lift (MAWL) and stated that relying on the RWL could lead to a weight limit that was impractical to realistically achieve in an industrial setting.[23] An additional study by Blanton[24] demonstrated that for certain obese individuals, the revised lifting equation does not limit L5/S1 compression forces to below the 3400 N recommended threshold.

While the RNLE can be used for a wide variety of material handling tasks, it does have some limitations. The tool is not designed for tasks involving one-handed lifting, carrying objects over long distances, pushing and pulling, lifting on a slippery surface, and tasks that require material handling for greater than 8 hours per day, to name but a few. Furthermore, a LI score of 1.0 or less does not necessarily mean that an entire workforce is safe from injury when performing an activity. The RNLE predicts that a lifting task that has an LI of 1.0 or less should be acceptable for 75% of female and 90% of male workers.[12] Lower percentile stature females particularly may lie outside of this population and therefore be at risk for lumbar injury performing activities that are within the recommended limits of the calculation. In addition, the NIOSH LI does not aid in the assessment of wrist, hand, shoulder, or neck injury risk. Tasks that involve grasping, pinching, and repetitive use of the upper extremities, primarily, must be evaluated by the use of other tools.

One such upper extremity ergonomic assessment tool is the Garg-Moore Strain Index. This tool is commonly used for tasks that involve fine manipulation, pinching, grasping, or using manual tools with the hands and wrists. Published by Arun Garg and Stephen Moore in 1995, the strain index is a semi-quantitative tool to assess the relative risk for developing cumulative trauma disorders of the distal upper extremity. It is based on the assessment of specific risk factors such as the speed of work, the position of the hand and wrist during work tasks, the force of exertion required, and the duration of the activity.[25] Each of the 6 risk factors has its own 5-tier rating criteria, with more hazardous positions, frequencies, etc. being awarded larger numerical multipliers (Table 3). The multipliers are presented in tabular form in Table 4. Some of the criteria are based on numerical values while others are derived from subjective descriptors. Some of the variables, such as frequency and duration, are relatively objective in nature as long as the assessor is accurate in his or her observation. Other variables such as the position of the hand and wrist and the force required during the task can either be quasi-objective or subjective depending on the method used to assess the job. Some raters get actual force requirements while others use estimations. Like the NIOSH lifting equation all of these individual numerical ratings are multiplied together. The product of all the variable multipliers is the strain index score. A strain index score of less than 3.0 is considered to be "safe" by the tool, while a strain index score greater than 7.0 is considered "hazardous" (Table 5).

There are several studies that examine the validity of the strain index. Garg et al[26,27] has found support for the strain index as an effective tool in multiple studies.Knox et al[28] also looked at the predictive value of the strain index in a turkey processing plant and found additional evidence of external and predictive validity. Pourmahabadian et al[29] also found a sig-

Table 2. The Cumulative Lifting Index

$CLI = LI_1 + LI_2(1/FM_{1+2} - 1/FM_1) + LI_3(1/FM_{1+2+3} - 1/FM_{1,2}) + L + LI_4(1/FM_{1+2+3+4} - 1/FM_{1,2,3})$. . .etc.
Abbreviations: CLI, cumulative lifting index; LI, lifting index; FM, frequency multiplier.

Table 3. Strain Index Multipliers

- **Intensity of Exertion:** The force required for a single performance of the task.
- **Duration of Exertion:** The proportion of the exertion cycle. Exertion cycle time is the average length of time associated with each exertion (including recovery time); the average length of the exertion divided by the cycle time multiplied by 100 gives the duration percent.
- **Efforts per Minute:** The frequency of exertion, and can be found from the exertion cycle time. (An exertion cycle time of 20 seconds is 3 efforts per minute.)
- **Hand/Wrist Posture:** A rated subjectively rather than by measurement; the authors prefer this to rigid categories of posture based on wrist angles.
- **Speed of Work:** A subjectively rated based on the observer's perception.
- **Duration per Day:** The total amount of time the job consumes.

nificant difference in the strain index between jobs identified as "safe" and those identified as "hazardous" in an electronics assembly plant.[29] The study did not, however, find a difference in absenteeism from work or employee turnover rate when comparing "safe" and "hazardous" positions. The strain index's ability to identify potentially harmful jobs was also supported by a study from Stephens.[29] It concluded that the strain index had test-retest repeatability when used by individuals or teams of evaluators. Inter-rater reliability was also examined in a study by Stevens et al.[30] These authors concluded there was strong inter-rater reliability of the strain index when addressing hazard classification in between both individuals as well as groups of individuals.

Despite the evidence for its effectiveness in assessing the risk of hand and wrist injuries, the applications for the strain index are limited. The underlying epidemiological research that went into its creation was based on injury data specific to the distal upper extremity. Therefore, the strain index does not address areas outside of the hand and wrist. The strain index is not appropriate for assessing the risk of developing such conditions as rotator cuff or lateral elbow injuries. In addition, the risk of nonrepetitive injuries such as falls onto the outstretched hand, lacerations, or contusions is not captured within this tool. The effects of vibration or the impact of blunt trauma on the upper extremity are also not included in the strain index.[6] Finally, like the RNLE, there exists a conundrum when one wishes to assess multiple, disparate activities within the same job. While workstations that require fairly repetitive, single-step tasks may be well-encapsulated by the basic strain index, the tool does not adequately reflect the cumulative effect of multiple, disparate activities upon the worker. To address this issue, Drinkhaus et al[33] presented an alternative method for calculating the impact of repetitive, variable work activities on the hand and wrist, the Cumulative Assessment of Risk of Distal Upper Extremity (CARD.) This tool is similar to the CLI in that it takes each task and ascribes a more comprehensive rating of the overall job instead of using the strain index score of the "maximum task approach" and just measuring the worst aspect of the job.[33]

In addition to limitations of the scope of the strain index, its lack of objectivity for some of the rating categories are shortcomings as well. Though the original article presents the percentage of a worker's maximum strength as one way to rate the intensity of exertion, the authors state that they do not recommend using such a measure in the workplace. They state that measuring a worker's force output using force gauges or other means is not "practical in the industrial setting due to technological and economic limitations."[25] Instead, they recommend that the rater use force estimates, like those of the Borg CR 10 Scale, to estimate the exertion level of the worker.[34] This more subjective method of rating the work task is also recommended by the authors when assessing the posture of the hand and wrist. They advise against attempting to perform goniometric analysis in the workplace. Instead, they recommend using qualitative descriptors such as "near neutral" and "marked deviation" to

Table 4. Strain Index Rating Values

Rating Value	Intensity of Exertion	Duration of Exertion	Efforts/Minute	Hand/Wrist Posture	Speed of Work	Duration per Day
1	Light	< 10	<4	Very good	Very slow	1 or less
2	Somewhat Hard	10-29	4-8	Good	slow	1 – 2
3	Hard	30-49	9-14	Fair	Fair	2 -4
4	Very Hard	50-79	15-19	Bad	Fast	4 – 8
5	Near Maximal	> 80	20 or greater	Very bad	Very fast	8 or more

Rating Value	Intensity of Exertion	Duration of Exertion	Efforts/Minute	Hand/Wrist Posture	Speed of Work	Duration per Day
1	1	0.5	0.5	1	1	0.25
2	3	1	1	1	1	0.5
3	6	1.5	1.5	1.5	1	0.75
4	9	2	2	2	1.5	1
5	13	3	3	3	2	1.5

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Table 5. Strain Index Scoring

SI <3: Safe
SI between 3 and 5: Uncertain
SI between 5 and 7: Some Risk
SI >7: Hazardous

categorize the position of the hand and wrist.

While the RNLE and the strain index have limitations, they both remain some of the most commonly used assessment tools within the ergonomics community. With the cost of ergonomic injuries estimated to be at over $50 billion per year, a method to quantify and rate the risk of physical activity in the workplace has become more widespread. These tools provide a method for quantifying the risk of lumbar and distal upper extremity injuries, respectively, and help companies to prioritize ergonomics improvement projects. As physical therapists continue to establish a niche within the ergonomics portion of the occupational health arena, tools such as these may become more common in the standard PT curriculum. If physical therapists are to maintain and even grow their presence in the world of ergonomics assessment, it is of paramount importance that they learn not only these tools but many others that are the cornerstones of common ergonomics assessment. Without them, credibility within the field is compromised and the viability of the physical therapist as an ergonomics resource will be jeopardized.

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