THE BENEFITS OF MANUAL MATERIALS HANDLING WEB-BASED EXERCISES

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***Abstract**: Scientific evidence shows that effective ergonomic interventions can lower the incidence and severity of musculoskeletal injuries caused by Manual material handling (MMH) tasks. Thus, teaching ergonomics must include both theoretical and practical exercises. Many online applications provide valuable user interface with a list of common MMH tasks. The calculator produce a number- percentage of individuals in the general population that could perform tasks without over exertion (the task which could be performed by 75 % of women, represents low-risk activity, while if the task can be performed by less than 10 % of men, it indicates high priority for task redesign) based on the NIOSH Lifting Equation. The advantages of the online application include capability to realistically simulate industrial work, having knowledge of how to perform planning in Warehouse management systems, and design jobs to allow sufficient rest for workers resulting in health improvement, psychological comfort and economic benefits.*

***Keywords:** Manual material handling, NIOSH Lifting Equation, Lifting Calculator.*

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1. INTRODUCTION

Material handling is a necessary, but wasteful and expensive activity in manufacturing and distributing. In most operations, material handling can account for 30-75% of an item's total production cost [5]. Moreover, in a typical manufacturing company, material handling accounts for 25% of employees, 55% of all factory space, and 87% of the production time [3].

Despite the tremendous advances in technology over the last thirty years, a significant portion of industry routinely handles materials without the benefit of ergonomic assist equipment or devices. As a result of this, lower back disorders and even disability continue to be a primary source of loss. Although the basic concept of ergonomics has been around for many years, the skyrocketing costs and the human suffering associated with lower back injuries and cumulative trauma disorders [8] has made ergonomics a major topic of interest today. Ergonomics, the science of designing work to fit the capabilities of workers, can be instrumental in improving a company's productivity. Ergonomics will continue to be a major opportunity for the material handling industry and to planners of manufacturing, warehousing and distribution systems. Proper ergonomics in these systems today increases production and quality along with decreasing medical costs, injuries, labour turnover and absenteeism [15]. These are contributing factors to the material handling industry's sustained leadership in the global market. Effective training is a key in delivering this type of workforce.

Injuries related to lifting are among the most disabling and costly of all workplace injuries, according to the 2012 Liberty Mutual Workplace Safety Index [18]. NIOSH (National Institute for Occupational Safety and Health) developed a tool used by occupational health and safety professionals to assess the manual material handling risks associated with lifting and lowering tasks in the workplace. The Lift Calculator, developed by NIOSH, has been used by employers and safety professionals for more than 30 years. For the last decade, companies such as Humantech [19] have used Excel spreadsheets to perform the calculations. The company's clients, who include distribution companies, auto suppliers, and heavy equipment employers requested an easier way to use the calculator. Now, an ergonomics company has created an application raising the NIOSH program to the next level of technology. Companies looking to reduce lifting-related risks to their employees can now use their smartphones or computer tablets.

2. ONLINE AND MOBILE LEARNING

Recent developments in information technology and telecommunications call for a serious reconsideration of the actual training methods and provide a wide opportunities for developing a new educational methodology. The main accent in development of both training and educational methods is put on using simulation techniques in developing new teaching material such as simulation-based case studies, simulation games, etc [14]. New training and educational methods like e-learning, m-training and any web-based learning become more and more popular.

Of the many different forms of ICTs, mobile phones are thought, for several reasons, to be a particularly suitable tool for advancing education in developing regions. They are the most prevalent ICT in the developing world, and their penetration rate is rising rapidly. The portability of mobile technology means that mLearning is not bound by fixed class times. MLearning enables knowledge acquisition at all times and in all places, during breaks, before or after shifts, at home, or when in motion. The ubiquity of mobile phones, moreover, means that educational services can be delivered with learners' existing resources. In as much as mobile technology presents a less cost-prohibitive medium for learning, it represents an important avenue by which to reduce the gap between the haves and the have-nots in contemporary society where access to knowledge and information is increasingly important [16], [9]. MLearning also facilitates designs for authentic learning, meaning learning that targets real-world problems and involves projects of relevance and interest to the learner [6], [4].

The new learning is personalized, learner-centred, situated, collaborative, ubiquitous, and lifelong. Likewise, mobile technology is increasingly personal, user-centred, mobile, networked, ubiquitous, and durable [12]. The literature indicates that the benefits afforded by this convergence should exert a positive impact on educational outcomes.

The applications used in mobile learning generally focus on brief interactions of perhaps several minutes or less, using simple navigation and graphics to accommodate multiple screen sizes. Such applications enable the quick review of information rather than prolonged or deep learning-as such, they are better suited for activities such as a status check, a request for just-in-time information, or as a student response tool in the classroom. Some exercises contain collaborative elements or game play, employing a variety of tools like social networking, calendars, customized calculators, simulations, or augmented reality. As learning management systems adapt to the mobile platform, m-learning may become a common tool for exploration by tech savvy faculty. The use of mobile devices seems a natural fit for distributed learning and field activities in that handheld technology can not only accompany the learner almost anywhere but also provide a platform that is rapidly evolving and always connected to data sources.

Many people in the not so distant future will start to see the mobile phone as an alternative to a PC. Some of the advantages of Mobile learning are :

- Mobile learning helps learners to improve their literacy and numeracy skills and to recognize their existing abilities
- Mobile learning can be used to encourage both independent and collaborative learning experiences
- Mobile learning helps learners to identify areas where they need assistance and support
- Mobile learning helps to combat resistance to the use of ICT and can help bridge the gap between mobile phone literacy and ICT literacy
- Mobile learning helps to remove some of the formality from the learning experience and engages reluctant learners [1], [2].

3. SAFE LIFTING CALCULATOR

The NIOSH Equation is a tool used by occupational health and safety professionals to assess the manual material handling risks associated with lifting and lowering tasks in the workplace. This equation considers job task variables to determine safe lifting practices and guidelines. The well known NIOSH Work Practices Guide for Manual Lifting can assist in determining which lifts are "safe" (that is, which lifts are associated with an acceptable risk) and which lifts are "unsafe" (that is, which lifts are associated with an unacceptable risk) [10]. With the help of the NIOSH *Guide*, employers can inventory lifting tasks assigned to their employees and then implement reasonable steps to control lifting related back injuries. Using the same guidelines, manufacturers can recognize the risk of back injury associated with their products and then design their products to eliminate such risk or properly label their products to warn and instruct about proper methods of lift. The revised equation was developed in 1991 to accommodate asymmetrical lifting and coupling and published in July 1993 [17].

Recommended Weight Limit (RWL) is the principal product of the revised NIOSH lifting equation. The RWL is the weight of the load that nearly all healthy workers could perform in a specific set of task conditions over a substantial period of time (e.g. up to 8 hours) without an increased risk of developing lifting-related low back pain. The revised lifting equation for calculating the RWL is based on a multiplicative model that provides a weighting for each of six task variables. The weightings are expressed as coefficients that serve to decrease the load constant. The load constant represents the maximum recommended load weight to be lifted under ideal conditions. The RWL is defined by the following equation: RWL = LC x HM x VM x DM x AM x FM x CM. Task variables needed to calculate the RWL:
H = Horizontal location of the object relative to the body; V = Vertical location of the object relative to the floor; D = Distance the object is moved vertically; A = Asymmetry angle or twisting requirement; F = Frequency and duration of lifting activity; C = Coupling or quality of the workers grip on the object.

The RWL can be used to guide the redesign of existing manual lifting jobs or to design new manual lifting jobs. For example, if the task variables are fixed, then the maximum weight of the load could be altered so as not to exceed the RWL. If the weight is fixed, then the task variables could be optimized so as not to exceed the RWL.

The lifting index (LI) provides a relative estimate of the level of physical stress associated with a particular lifting task. It is defined by the relationship of the weight of load lifted (L) and the RWL. In equation form this index is LI = L/RWL. If the magnitude of the LI increases the level of the risk for the worker performing the job would be increased or a greater percentage of the workforce is likely to be at risk for developing lifting- related low back pain.

3.1 Online Application

Based on the NIOSH Equation and Snook and Ciriello tables [13], an Excel version of this tool will be presented as a valuable application for online learning. NIOSH Lifting Equation Calculator could be assessed from http://www.ergoplus.com/healthandsafetyblog/ergonomics/niosh-lifting-equation-single-task/ where "A Step by Step Guide to Using the NIOSH Lifting Equation for Single Tasks", by Mark Middlesworth could be found. Two cases, one with nominal risk, and the other where engineering or ergonomic intervention should be implemented are presented in Figure 1 and 2 (respectively). Upon entering the necessary information, the calculator suggests if the lifting task is safe or if changes are needed. It is obvious how, by varying the relevant parameters in the equation, the outcome changes.

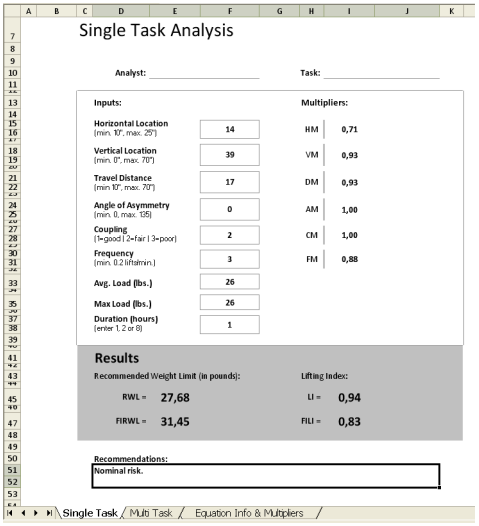

Figure 1. Risk assessment using NIOSH Lifting Equation calculator (case of nominal risk)

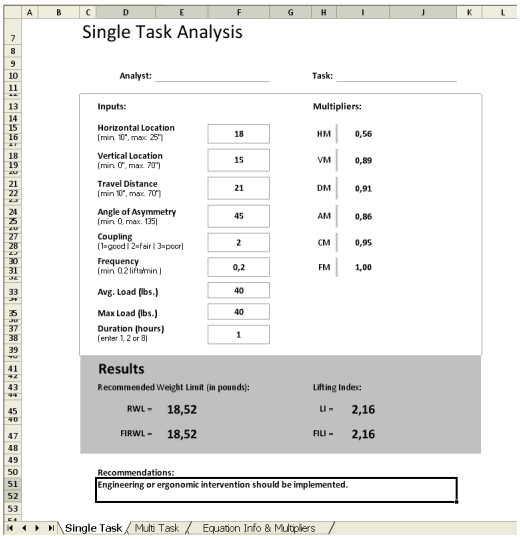

Figure 2. Risk assessment using NIOSH Lifting Equation calculator (case where engineering or ergonomic intervention should be implemented)

3.2 Mobile Application

Another, more interesting is mobile application- Oregon OSHA's easy lift app which uses a modified version of the NIOSH lifting equation to give the user a maximum safe weight for various lifting scenarios. By inspection the Google Play App Store, Safe Lifting Calculator was found to be available for unconditional usage. The use of the following steps will assist in determining a safe working weight. Factors based on, starting position, repetition, and duration of the task will be used to calculate the maximum weight that may be lifted safely. The

purpose of this calculator is to identify the lifting limit and ensure that starting weight does not exceed the lifting limit. The first step is to select the position of hands when starting to lift or lower the objects, i.e. above the head, below the knees, close/away from the body etc. Than, the number that corresponds to the times the person lifts per minute and the total number of hours per day spent lifting will be selected.

Figure 3. Example when Weight Lifted (14-17 lbs.) represents moderate risk for injury requires to consider controls to reduce or eliminate risks

The calculator indicate the maximum safe lifting limit we should use (Fig. 3). In the first example the hands position when starting to lift or lower the objects is below the knees, in the middle position, with the frequency of lifting of 2-3 lifts every min for 1-2 hours, the maximum safe lifting limit if the task involves twisting 45 degrees or more will be 14 lbs. or (6.35 kg), while for the job which requires twisting under 45 degrees, the allowed weight will be 17 lbs. (7.71 kg).

Figure 4 shows that when the hands position when starting to lift or lower the objects is at the top of head level up to 3 inches below the shoulder, with the same lifting frequency as in the above example, the calculator show that the acceptable maximum weight if the task involves twisting 45 degrees or more will be 7 lbs. or (3.18 kg), while for the job which requires twisting under 45 degrees, the allowed weight will be 8 lbs. (3.63 kg).

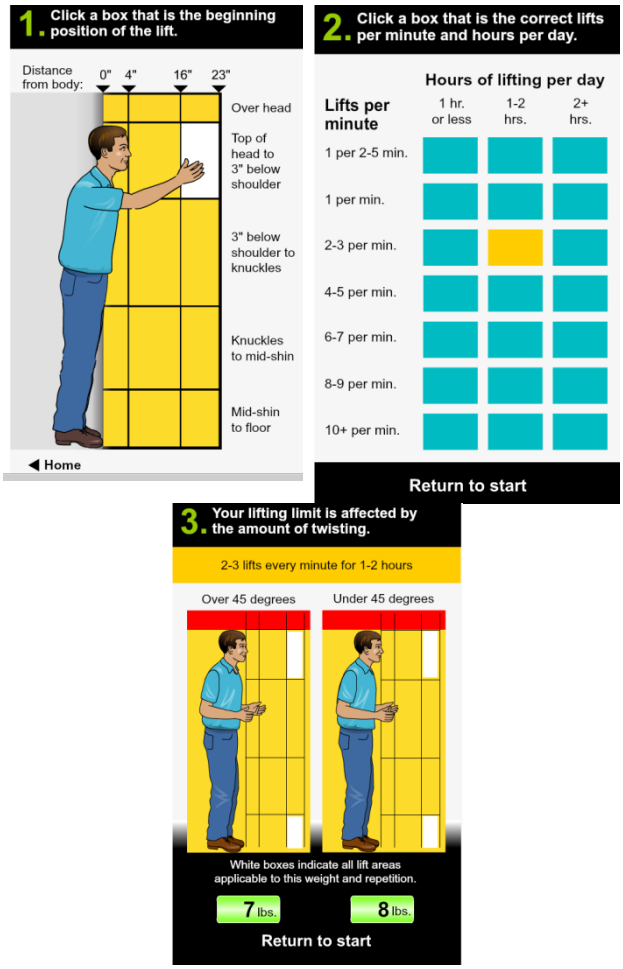

Figure 4. Example when Weight Lifted (7-8 lbs represents high risk for injury, controls to reduce or eliminate risks required

In the case of the same lifting frequency, the vertical hands position and the distance from the body determines the maximum safe lifting limit, the higher hands position and the distance from the body, leads to decreasing of the maximum object weight. When the lifting frequency remains the same, but the hands position is between waist and shoulder and away from the body, this lift/lower presents high risk for injury and requires controls to reduce or eliminate risks as soon as possible (Fig. 5).

Finally, with increasing lifting frequency of more than 10 lifts every minute within 1 hour, the maximum acceptable weight is very low, if the task involves twisting 45 degrees or more it will be 3 lbs. or (1.36 kg), while for the job which requires twisting under 45 degrees, the allowed weight will be 4 lbs. (1.81 kg) as could be seen from Fig. 6.

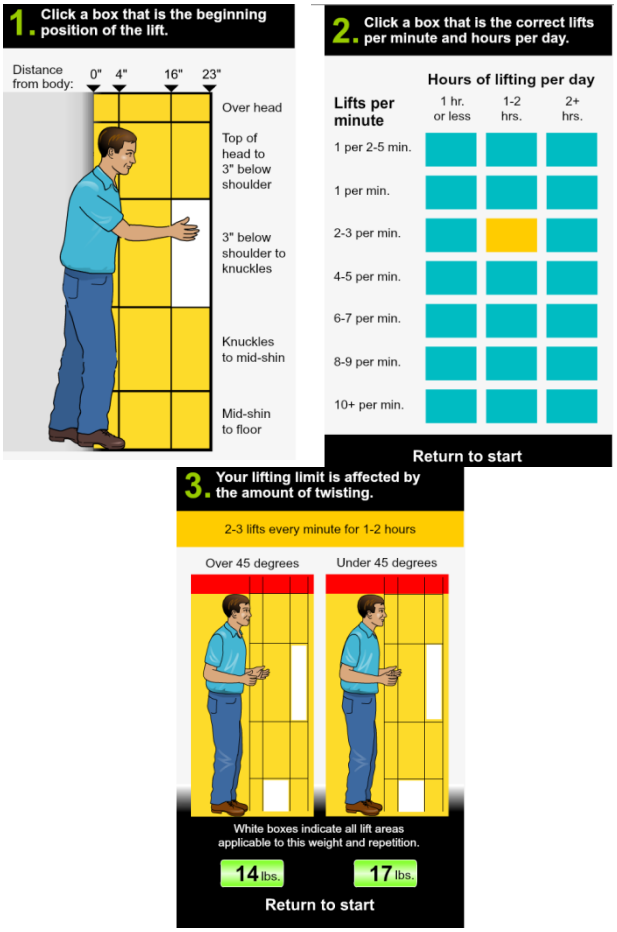

Figure 5. Example when Weight Lifted (14-17 lbs.) represents moderate risk for injury requires to consider controls to reduce or eliminate risks

4. CONCLUSION

The main advantage of this application is that it provides extremely fast, real-time feedback. Managers or workers need the reliable data about risks and stress on the low back, when on the manufacturing floor, when they are in the warehouse, on the assembly line, right beside the conveyor belt, etc., but without taking relatively heavy laptops. Now it can be done using tablets or smartphones. The application determines the risk level for any particular lifting task. It can be used at the job site to evaluate both existing and proposed lifting conditions to determine the Recommended Weight Limit (RWL) for a specific job or task, and could identify those jobs or tasks that might require ergonomic intervention. The platform also gives opportunities for improvement. It shows the relative contribution of each variable - factor and tells about the biggest impact on how safe this lifting task is, so how should, for example, the horizontal reach from one to another point be reduced, in other words, it suggests ergo solution. All the information could be shared across the company platform and collaborating to minimize risk.

Each of the two presented applications has its benefits, online application provides a comprehensive insight in the different variables of the task, and the manner how their values vary according to the job demands. On the other hand, the mobile application contains fewer details, giving faster feedback, but its' distinctive peculiarity and advantage is mobility, i.e. the possibility to be used on different mobile devices.

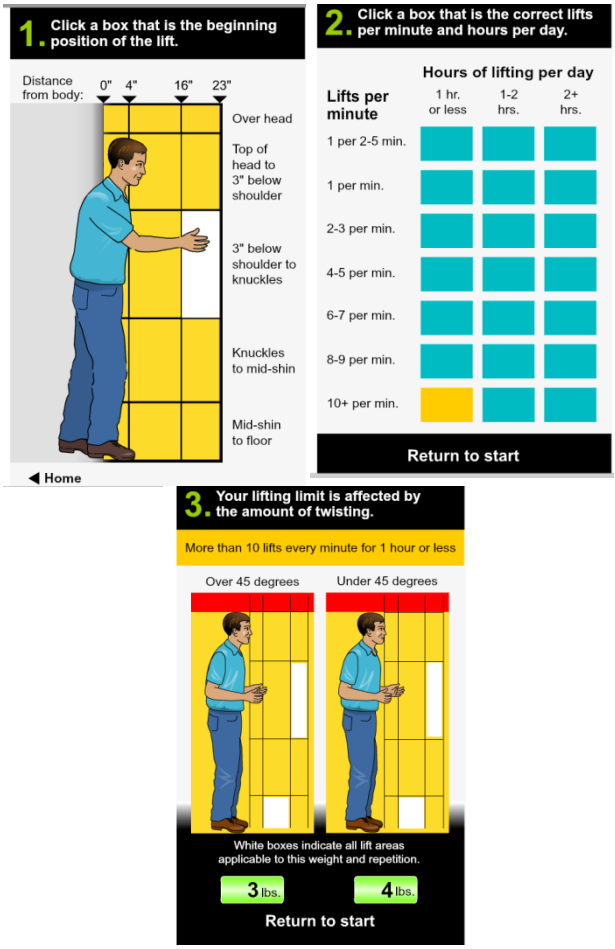

Figure 6. Example when Weight Lifted (3-4 lbs.) represents high risk for injury, controls to reduce or eliminate risks required

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