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Developing Medical Laboratories Ergonomics Appraisal Model in Medical Laboratories Operations Lifting Process Through Applying Revised NIOSH Lifting Equation

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Abstract

This paper focuses on the ergonomics evaluation of medical laboratories. The basics questions for this research were What are the key ergonomics matters in the safe and effective use of Laboratories Medical Equipment (LME)? And how we can estimate LME in the early phases of the Laboratories design procedure. The goals of the research were to establish an ergonomics appraisal model for the of LME and to determine the key ergonomics affairs in the lifting as well as in the usage of LME. We conducted an encounter with laboratory engineers, operators and technicians; with a wide variety of specialization to reconnoiter substantial affairs as well as troubles resulted by LME. 7 key connotations were selected as the core elements of the ergonomics appraisal model that is the essential output of this research, these key connotations are maximum weight that could be lifted under ideal circumstances, Horizontal distance of hands from midpoint between the ankles, Angle of asymmetry – angular displacement of the load from the sagittal plane, Average frequency rate of lifting measured in lifts/minute and office usage.

Keywords: Ergonomics appraisal model; Laboratories Medical Equipment (LME), Revised NIOSH Lifting Equation.

Introduction

Laboratories Medical Equipment (LME) are improved and delineated for the informational and computational needs of chemical engineers, technicians as well as other medical personnel who are employed mainly in the medical laboratories. However, LME can be a serious source of potential health hazards for their utilizers. Unnatural postures and positions mobile usage of LME may result in serious health hazards. Most LME utilizers has the same anthropometry; however, their ways of LME interaction are different. A large number of medical laboratories designs can be found in reality, many of them taking account in consider the National Institute for Occupational Safety and Health (NIOSH) revised equation [1].

This equation suggested Recommended Weight Limit (RWL) for lifting which is a recommended load that healthy workers can do for up to 8 hours without increasing the risk of Musculoskeletal Disorders (MSD) to the lower back. RWL is related to Load Constant (LC) of 23 Kg and several multipliers (Horizontal multiplier (HM), Vertical Multiplier (VM), Distance Multiplier (DM), Asymmetric Multiplier (AM), Frequency Multiplier (FM) and Coupling Multiplier(CM)). The multipliers range from 0 to 1. A value of 1 for the multiplier represents good working posture and a value of 1 represents improper posture, high frequency, or difficult working environments. Hence the maximum RWL limit is LC, when all multipliers are 1. If any multiplier moves toward 0, then the RWL reduces towards 0 [2].

The RWL is calculated by applying the following equation:

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM \qquad (1)$$

This study is based on the physical ergonomics evaluation of LME design and it aimed to determine LME utilizers requirements to including them as appraisal model in the concept and schematic design phases.

The concentration of the planned study will be determining the RWL and a Lifting Index (LI) which is estimated to present a relative estimate of the grade of physical stress and MSD risk related with the manual lifting jobs predestined.

A LI value of less than 1.0 points out a nominal risk to healthy employees. A LI of 1.0 or more symbolizes that the job is high risk for some percentage of the population. As the LI increases, the level of MSD and low back injury risk increases correspondingly. Therefore, the aim is to design all lifting tasks to achieve a LI of less than 1.0.

LI is calculated using the following equation:

$$\text{Lifting Index (LI): Weight} \div RWL = LI \qquad (2)$$

The RWL and LI can be utilized to instruct lifting job design in the following possibilities: 1) The individual multipliers that define RWL can be applied to determine specific impairment in the design. 2) The LI can be applied to rate the relative physical stress and harm risk for a job. The higher LI worth, the smaller the percentage of workers able to safely doing these task requirements. Thus, harm jeopardy of two or more job designs could be compared. 3) The LI can also be applied to prioritize ergonomic redesign efforts. Jobs can be graded by LI and a control strategy can be executed based on a priority rank of individual lifting jobs [3].

Literature Review:

Kim et al, presented a smart cart system which aids employees to do an efficient picking operation without human errors or cost problems. They surveyed their research using 31 participants. They surveyed on which location of touch screen (i.e. 250mm and 450mm from cart handle) was more assuasive in relation to human body parts. They also asked participants which angle of handle (i.e. vertical, 45 degree tilted and horizontal) was most assuasive, again in relation to body parts. Lastly, participants were demanded which picking way among pick-by-cover and pick-to-light was more assuasive during the research [4].

Alhorr et al, explored the problems encountered in the Qatari healthcare sector regarding Health Associated Infections (HAI) and healing environment. They found that there is a necessity for more research in the fields of knowledge and performance management to better keep healthcare facilities. The design of healthcare facilities and the applying of green building guidelines in Qatar also need to integrate design practices and features that can enhance healing and have been researched in other parts of the world [5].

Leva et al, summarized current industrial trends and standards promoting Human Factors Engineering (HFE) at design phase and review them with an action research approached based on the concrete case studies done during a European project called TOSCA [6].

They highlighted how HFE can significantly affect the costs and risk related with a plant lifecycle and the current gaps and issues faced. The gaps defined are utilized to instruct industrial practices and standards for a more valuable inclusion of Human Factors knowledge in structured system design processes to support human performance and minimize the potential for human errors in operations and maintenance.

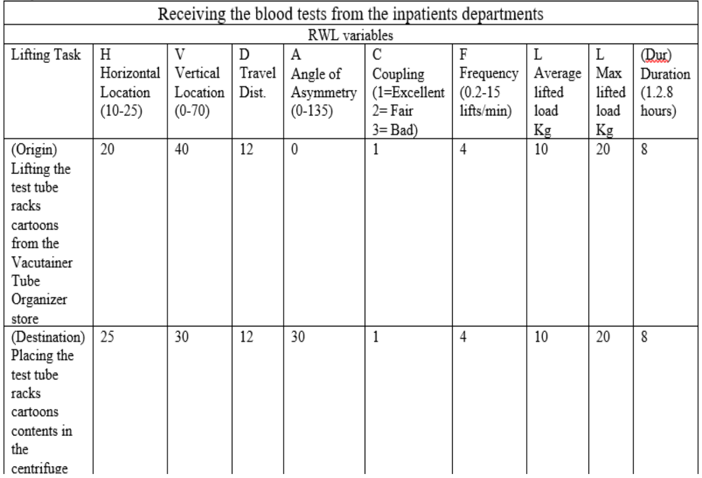
Harona et al, reviewed the literature on “usability concept” in built environment and healthcare design, and propose a possible usability conceptual framework in achieving quality service. This paper will concentrate on three usability main factors: efficiency, effectiveness and user’s contentment. This overview will aid future researchers to explore the link between spatial design and “usability concept” from the user’s experience and anticipation of the outpatient area as part of the Malaysian Primary Healthcare (MPHC) service in a public hospital. This usability is advantageous in enhancing outpatient area service outcome, which is more worthy to the end-utilizers [7].

Methodology

An encounter with end-utilizers was conducted to gather information about the needed data and measurements for lifting task variables utilized for calculating the RWL and LI of LME for the tasks being estimated.

For every lifting task analyzed, the chemical engineer will need to determine the task variables as outlined in the following table:

Figure 1. RWL variables



Receiving the blood tests from the inpatients departments									
RWL variables									
Lifting Task	H Horizontal Location (10-25)	V Vertical Location (0-70)	D Travel Dist.	A Angle of Asymmetry (0-135)	C Coupling (1=Excellent 2= Fair 3= Bad)	F Frequency (0.2-15 lifts/min)	L Average lifted load Kg	L Max lifted load Kg	(Dur) Duration (1.2.8 hours)
(Origin) Lifting the test tube racks cartoons from the Vacutainer Tube Organizer store	20	40	12	0	1	4	10	20	8
(Destination) Placing the test tube racks cartoons contents in the centrifuge	25	30	12	30	1	4	10	20	8

In our case study, we followed the following steps to determine each RWL variable:

1) Horizontal Position of the Hands (H): To calculate this variable, we scaled and registered the horizontal position of the hands at both the origin and destination of the lifting job. The horizontal position is scaled as the space (cm) between the employee’s ankles to a point projected on the floor directly below the mid-point of the hands grasping the object as shown below:

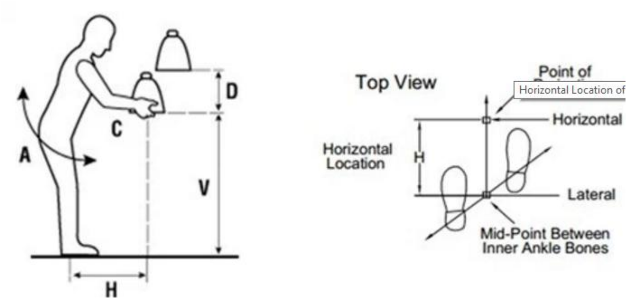


Figure 2: Horizontal Position of the Hands (H)

2) Vertical Position of the Hands (V) – To calculate this variable, we scaled and registered vertical location of the hands above the floor at the origin and destination of the lifting job. The vertical Position is scaled from the floor to the vertical mid-point between the two hands as shown in the figure below. The middle knuckle can be used to define the mid-point as shown below:

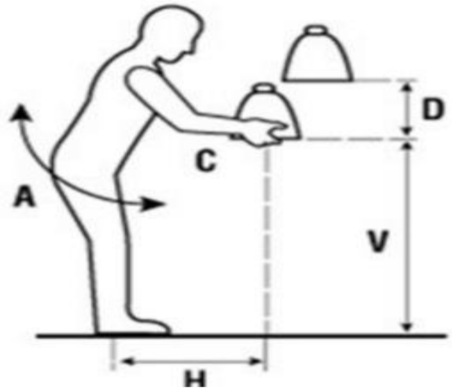


Figure 3: Vertical Position of the Hands (V)

3) Vertical Travel Distance (D) – To calculate this variable, we subtracting the vertical location (V) at the start of the lift from the vertical location (V) at the end of the lift. For a lowering task, subtract the V location at the end from the V location at the start as shown below:

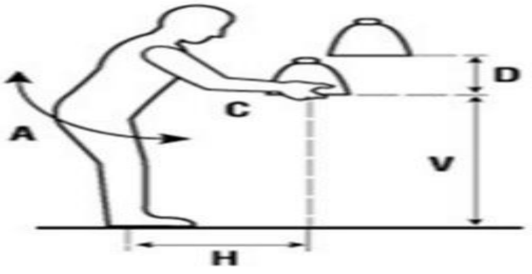


Figure 4: Vertical Travel Distance (D)

4) Asymmetric Angle (A) – To calculate this variable, we scaled the degree to which the employee is required to twist or turn during the medical equipment carrying job. The asymmetric angle is the amount (in degrees) of trunk and shoulder rotation required by the lifting task. It is calculated by determining the number of degrees the back and body trunk must twist or rotate to achieve the lift. (i.e. 90° as illustrated below:

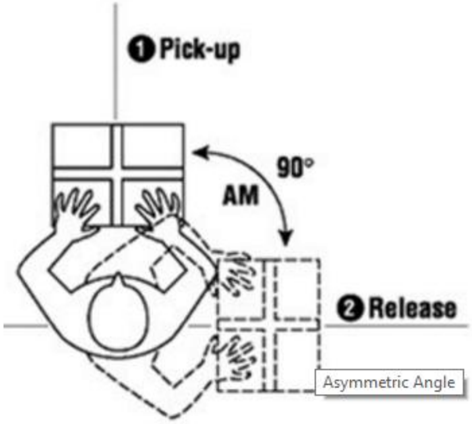


Figure 5: Asymmetric Angle (A)

5) Coupling (C) – To calculate this variable, we estimated the rating of the quality of the coupling between the employee's hands and the medical equipment as Excellent, fair, or Bad (1, 2, or 3). An Excellent coupling will minimize the maximum grasp forces needed and increase the acceptable weight for lifting, while a bad coupling will generally require higher maximum grasp forces and minimize the acceptable weight for lifting.

6) Frequency (F) – To calculate this variable, we estimated the suitable lifting frequency of lifting jobs by applying the average number of lifts per minute during an average 15-minute sampling period. For instance, enumerate the total number of lifts in a typical 15-minute period of time and divide that total number by 15.

- Minimum = 0.2 lifts/minute
- Maximum is 15 lifts/minute.

7) Load (L) – To calculate this variable, we estimated the weight of the medical equipment to be lifted.

8) Duration (Dur) – To calculate this variable, we estimated the carrying duration as rated into one of three categories:

- 1 = Short – carrying ≤ 1 hour with recovery period ≥ 1.2 X work period
- 2 = Moderate – carrying between 1 and 2 hours with recovery period ≥ 0.3 X carrying period
- 8 = Long – carrying between 2 and 8 hours with standard rest allowances

In the following step, we applied these steps to calculate the RWL for receiving the blood tests from the inpatients departments in the medical laboratory reception section and we got the following table:

Table 1. RWL case study parameters values

Lifting Task	H Horizontal Location (10-25)	V Vertical Location (0-70)	D Travel Dist.	A Angle of Asymmetry (0-135)	C Coupling (1=Excellent 2= Fair 3= Bad)	F Frequency (0.2-15 lifts/min)	L Average lifted load Kg	L Max lifted load Kg	(Dur) Duration (1.2.8 hours)
(Origin) Lifting test tube racks cartoons from the Vacutainer Tube Organizer store	20	40	12	0	1	4	10	20	8
(Destination) Placing the test tube racks cartoons contents into centrifuge	25	30	12	30	1	4	10	20	8

The final step represented by calculating RWL was achieved by applying equation 1 as follow:

Table 2: RWL and LI values calculations

Load	23	23
Horizontal multiplier (HM)	0.89	0.625
Vertical Multiplier (VM)	0.95	0.98
Distance multiplier (DM)	1.00	1.00
Asymmetric Multiplier (AM)	1.00	0.90
Frequency Multiplier (FM)	0.80	0.80
Coupling Multiplier(CM)	1.00	1.00
Recommended Weight Limit	15.55	10.14
Lifting Index (LI)	0.64	0.98

Results and Discussions

Studying the lifting situation in the medical field is a vital topic because it can avoid causing severe medical problems like Musculoskeletal Disorders.

The RWL represents Recommended Weight Limit (RWL) for lifting which is a recommended load that healthy workers can do for up to 8 hours without increasing the risk of Musculoskeletal Disorders (MSD) to the lower back.

The factors affecting the RWL are: (Horizontal multiplier (HM), Vertical Multiplier (VM), Distance Multiplier (DM), Asymmetric Multiplier (AM), Frequency Multiplier (FM) and Coupling Multiplier(CM)).

The Lifting Index (LI) represents a relative estimate of the grade of physical stress and MSD risk related with the manual lifting jobs predestined.

When analyzing the RWL situations in our case study, we have two position analysis summaries:

- Origin Summary: The average weight to be lifted (10 Kg) is less than the RWL at the origin (15.55 Kg), however the maximum load to be lifted (20 Kg) is greater than the RWL. The LI is .64 indicating a nominal overall risk to healthy employees and a slight risk when lifting the maximum load of (20 Kg) from the origin.

- Destination Summary: The average weight to be lifted (10 Kg) is less than the RWL at the destination (10.14 Kg) and the maximum load to be lifted (20 Kg) is greater than the RWL. The LI is .98 indicating a nominal risk to healthy employees at the destination.

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