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Different Evaluation Techniques for Manual Material Handling

Engineering

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ABSTRACT

In this present paper, some of manual box lifting techniques are reviewed which are generally used by Industries globally. Different manual box lifting methods have different impact on heart rate (HR) and oxygen consumption (VO2) and related factors while doing a manual lifting task. Box shape and type with maximum lifting frequency increases the HR, VO2, L4/L5 compression force and other related human factors during manual lifting task and also increases the fatigue. In order to minimise the effects of box lifting on these factors and fatigue we have to practice on new and better manual box lifting techniques and we have to use some precautions based on physiological, biomechanical and psycho physiological approach.

1. INDUSTRIAL BACKGROUND OF MANUAL BOX LIFTING TASKS

Most packaging industries use manual box lifting tasks for the delivery of finished products. Examples include Oil industry, food processing industry, machine spare part industries which require the manual box lifting for finished packed products. Different types of boxes are used for packaging of juice cans, oil cans, milk packets, machine parts, domestic glass and steel utensils. In the mass production industries repeated manual box lifting task is done for lifting the boxes from floor to rack. Repeated manual lifting of different type of boxes to various vertical heights generally affect the HR and VO_2 of Indian industrial labour and results to maximum fatigue. Bad effect of repeated manual box lifting on HR and VO_2 can be minimised by proper designing of manual lifting techniques.The review of the literature was done under the main types of manual load lifting approaches by consulting relevant literature and internet sources. The sources used in the research include Science Direct, and www.tandfonline.com. The Goggle and Yahoo search engines were used to search the sources of the literature. The searching was done using the terms such as manual lifting, box lifting, and effect of lifting frequency on HR. The results of the findings are presented**.**

2. TECHNIQUES TO EVALUATE MANUAL MATERIAL LIFTING (MML) TASK

Three basic techniques are generally used for evaluating the manual material lifting task. These techniques are categorised as physiological, biomechanical and psycho physiological. These are briefly defines as given below.

2.1 PHYSIOLOGICAL

When a manual material handling job requires highly repetitive, fast paced or forceful exertions and fatigue must be considered. Each person has a unique physical work capacity which is a measurement of maximum aerobic capacity or metabolic expenditure capabilities. This approach presumes that the load is within the physical strength of workers. A person endurance is primary limited by the capacity of oxygen transport system. Increased metabolism demands an increase in the delivery of oxygen and nutrients to the tissue if the activity is to be continued once muscles become activate. HR, Max. VO_2, blood pressure is common physiological responses use to measure physiological stress. The physiological variables as reported by include pulmonary ventilation, oxygen uptake, energy expenditure and heart rate. HR increases significantly with increase in frequency (Cheng te-Shiang and Lee hsien tzu, 2006; Wn Pi Swei, 1997; Wu Pi Swei; Chen Ping Jing, 2003. The idea of VO_2 consumption previously given by (Wu Pi Swei, 2000) that with increase in lifting frequency the amount of vo2 consumption also increases.

2.1.1 HEART RATE

Heart rate (HR) refers to the speed of the heartbeat, specifically the number of heartbeats per unit of time. The heart rate is typically expressed as beats per minute (bpm). The heart rate can vary according to the body's physiological needs, including the need to absorb oxygen and excrete carbon dioxide. The normal heart rate ranges from 60-100 bpm. Heart rate is measured by finding the pulse of the heart.
(Source: http://en.wikipedia.org/wiki/Heart_rate)

2.2.2 VO2

VO_2 max (also maximal oxygen consumption, maximal oxygen uptake, peak oxygen uptake or maximal aerobic capacity) is the maximum capacity of an individual's body to transport and use oxygen during incremental exercise, or labour work which reflects the physical fitness of the individual. The name is derived from V - volume, O_2 - oxygen, max - maximum.

VO_2 max is expressed either as an absolute rate in litres of oxygen per minute (L/min) or as a relative rate in millilitres of oxygen per kilogram of bodyweight per minute (ml/kg/min). Table 1 & 2 represents the maximum oxygen uptake by men and women.
(Source: http://en.wikipedia.org/wiki/VO2_max)

Table 1.
Maximal oxygen uptake norms for men (ml/kg/min)

	18-25 Years old	26-35 Years old	36-45 Years old	46-55 Years old	56-65 Years old	65+ Yeras old
Excellent	>60	>56	>51	>45	>41	>37
Good	52-60	49-56	43-51	39-45	36-41	33-37
Average	47-51	43-48	39-42	35-38	32-35	29-32
Average	42-46	40-42	35-38	32-35	30-31	26-28
Average	37-41	35-39	31-34	29-31	26-29	22-25
Poor	30-36	30-34	26-30	25-28	22-25	20-21
Very poor	<30	<30	<26	<25	<22	<20

Source: http://haroldgibbons.com

Table 2.
Maximal oxygen uptake norms for women (ml/kg/min)

	18-25 Years old	26-35 Years old	36-45 Years old	46-55 Years old	56-65 Years old	65+ Yeras old
Excellent	56	52	45	40	37	32
Good	47-56	45-52	38-45	34-40	32-37	28-32
Average	42-46	39-44	34-37	31-33	28-31	25-27
Average	38-41	35-38	31-33	28-30	25-27	22-24
Average	33-37	31-34	27-30	25-27	22-24	19-22
Poor	28-32	26-30	22-26	20-24	18-21	17-18
Very poor	<28	<26	<22	<20	<18	<17

Source: http://haroldgibbons.com

2.2 BIOMECHANICAL

Biomechanical methods use posture, gender, anthropometry (body size) and push/pull or compressive forces to calculate resultant muscle force requirement and joint compression forces.

Biomechanical techniques are useful when analyzing high exertion tasks, but often do not consider the effect of dynamics, repetition or duration of the work task or job. The primary biomechanical criteria used for study of MMH task are based upon spinal compression and maximum torque capabilities of the various major joints involved in performing a task. Biomechanical data is collected empirically from laboratory experiments, or derived from mathematical modelling of the human body and the forces acting upon it.The most commonly used criteria are compression limits for the L4/L5 or L5/S1 Joints, and / or maximum joint torques (**Waters TR, et al, 1993).** The compression limits for the L4/L5 or L5/S1 Joints are usually derived from cadaver studies of spinal failures while maximum joint torques are derived from the results of empirical studies in which the maximum voluntary contraction capability of joints are collected from a group of subjects as observed by **(Dempsey P.G, 1998).** Some authors **(Jager M., Luttmann, 1989, 1999)** used the peak compressive force on the lumbar spine and found that lumbar vertebral units failed at compressive loads.

2.3 PSYCHOPHYSIOLOGICAL

This technique is basically used in manual material lifting (MML) to determine the Maximum acceptable weight limit (MAWL). To find the MAWL for MMH tasks (lifting, lowering, pushing, pulling, and carrying) the psychophysical approach proposed by **Snook (1978)** has been extensively used. **Snook (1978**) had proposed the use of experimental procedures to determine the subject's preference for weight to be lifted under given task conditions by which a subject selects a weight randomly, In simple terms psychophysics is the research method that takes human perceptions in to account.. **Snook** and his co-researchers continued their research using the psychophysical approach as reported by **(Snook S.H, 1978; Snook S.H., Ciriello V.M, 1991**; **Ciriello V.M., Snook S.H., Hughes G.J, 1993)** and were joined by others such as **(Dempsey P.G., Ayoub M.M, 1996; Karwoski W., Yates J.W,1986)** using this approach. Liberty mutual successfully applied the method to lifting/ lowering tasks, carrying tasks and pushing/ pulling tasks. For these they developed a set of guidelines based on these key factors.

1. Type of task
2. Type of force
3. Gender of the person
4. Percent of the industrial working population that should be able to safely perform.
5. Frequency of repetition of the task

3. THE NIOSH EQUATIONS

The National Institute of Occupational and Safety Health (NIOSH) constitute a team of experts in 1985 to review literature on lifting including the NIOSH Work Practices Guide of 1981. This revised edition became the 1991 lifting equation which reflected new findings and provide methods for evaluating asymmetrical lifting tasks, objects with less than optimal handcontainer couplings and offers new procedures for evaluating a large range of work durations and lifting frequencies than the 1981 equation. The 1991 lifting equation is more accurate given by NIOSH is more likely to protect most workers than the 1981 equation **(Liles D.H., Mahajan P, 1985)**

The reasons are that:

1. The 1991 equation is applicable to a wider variety of lifting jobs because of the addition of the asymmetric and coupling multipliers.
2. The recommended weight limits computed are generally lower than the Maximum Acceptable Weight Limits reported by **(Snook S.H., Ciriello V.M,1991)**

However, some authors **(Waters T.R., Putz-Anderson V., Garg A., Fine L.J, 1993)** reported that the NIOSH Committee noted that due to uncertainties in the existing scientific studies and theoretical models, further research was needed to assess the magnitude of risk for lifting- related low back pain and its association with the lifting index. Table 3 shows the comparison between the 1981 and 1991 NIOSH equations.

Table 3 Comparison between the 1981 and 1991 NIOSH Equations

Components	1981 Equation	1991 Equation
LC = Load Constant	40kg	23kg
HM =Horizontal Multiplier	15/H	25/H
VM = Vertical Multiplier	1-0.004(|V-75|)	1-0.003(|V – 75|)
DM = Distance Multiplier	0.7 + 7.5/D	0.82 + 4.5/D
AM = Asymmetric Multiplier	Not Available	1-0.0032A
FM = Frequency Multiplier	1-F/Fmax	From Table
CM = Coupling Multiplier	Not Available	From Table

H = Horizontal distance of hands from midpoint between the ankles (cm).
V = Vertical distance of the hands from the floor
D = Vertical travel distance between the origin and destination of the lift (cm).
A = Angle of asymmetry – angular displacement of the load from the sagittal plane.
F = Average Frequency rate of lifting measured in lifts/min.
1981 Equation (Action Limit): AL = LC × HM × VM × DM × FM - Eq(1)
1991 Equation (Recommended Weight Limit): RWL = LC × HM × VM × DM × AM × FM × CM - Eq(2)

CONCLUSIONS

From the research reported by different researchers it can be concluded that the MMH tasks are generally evaluated by physiological, biomechanical and psychopysiological technique by finding VO_2 and HR, L4/L5 compression force and MAWL. An industrial labour uses normal techniques to lift different types of boxes to various heights which increase the heart rate, oxygen consumption and other parameters. So to minimise these significant effects on heart rate, VO_2 and other factors we have to discover new simple and easy manual lifting techniques.

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