A Study of Virtual Environment of Safe Lifting Works for Reducing Low Back Injuries

Kim, Dae-Sik*
Kang, Kyong Sik**

ABSTRACT

Today, technologies and automation have been accelerated up in the industrial workplace. Nevertheless, many systems still require humans to handle materials manually. The Low Back Pain (LBP) is one of modern human being's most common and complex ailments. Many risk factors with the onset of LBP have been identified, however, lifting out of Manual Material Handling(MMH) was the most important factor to the LBP. The Virtual Reality(VR) is used in a variety of ways and often in a confusion and misleading manner. In order to solve the prevention of the LBP, a lifting box was translated in the Virtual Environment(VE). As simulating under the VE, optimal lifting works could be constructed. The purpose of this study is to reduce the chronical low back pain for the manual material handlers.

1. INTRODUCTION

Many of the systems and equipment will not run without the presence of humans who can be the prime movers, the controllers and the decision makers. In spite of the technological advances and extensive use of automation in the industrial workplace, many workers are still required to handle materials manually in their daily jobs. This environment involves a potential danger to the worker and might expose him/her to an injury or possibly death. In most manual material handling(MMH) tasks, the worker must assume an awkward posture to perform the task and/or his entire muscular system must brought into action.

* Dept. of Industrial Engineering, Ansan College of Technology
** Dept. of Industrial Engineering, Myong Ji University

The total injuries due to MMH task was the first major cause and 330(10.48%) out of the total amount of injuries (3,150). ('97 Industrial Injury Analysis, Ministry of Labor) The major cause out of classification was the injury due to fracture (1,267, 40.22%) and the fourth was the injury due to Low Back Pain (153, 4.86%). The low back injuries of 70(45.75%) was occurred at the manufacturing industry out of total 153 LBP. The total injured body parts with spine and torso was 548(17.40%) out of the total of 3,150 injuries.

To prevent the low back injuries, the simulation of MMH tasks under the virtual environment was suggested. The terms of virtual reality(VR) is the methods of involvement and interaction for humans with a computer-generated graphical environment. The development of simulator of the safe lifting performance is desirable in this study.

The Purpose of this paper is to reduce the chronical low back pain for the manual material handlers.

This paper is to:

(1) analyze occupational illness of low back pain(LBP) on working of manual material handling(MMH), and

(2) translate a lifting box in the VE.

2. RISK FACTORS OF LOW BACK PAIN

The LBP is one of modern human being's most common and complex ailments. It has been estimated that almost eight out of every ten people, at some time in their lives, will experience back pain. LBP is not a disease, rather it is a number of pathologic conditions, all of which cause pain. Backache can strike almost anyone: the young and the old; male and female; people of all classes, races, educational levels, and professionals. LBP ranks first among all health problems in frequency of occurrence. It is second only to common respiratory infection as a source of lost time payment claims. LBP is the leading cause of activity limitation among young people.

Many risk factors associated with the onset of LBP have been identified(Table 1). They vary widely based on the population studied and the conditions under which the study was conducted. Whether these factors represent the cause of injury, events leading to injury, or results of the disability is unclear. Specifically, in workplace LBP is often associated with industrial-type activities,

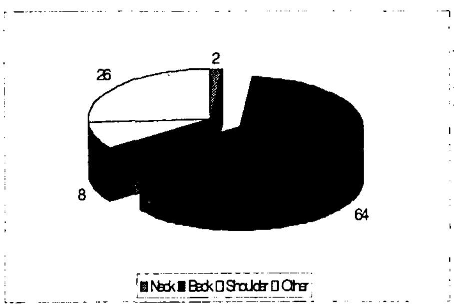
[Table 1] Risk Factors

1. Physical Factors		
posture	strength	flexibility
body build	reflexes	aerobic capacity
2. Individual Factors		
age	weight	previous injury
nutrition	fitness level	education
income	alcoholic use	medical history
degeneration	smoking	
gender	height	
3. Psychological Factors		
depression	marital discord	family problems
anxiety	job dissatisfaction	personality traits
attitudes toward work		
4. Environmental Factors		
prolonged sitting	years on job	climate
accidents	driving	**lifting (amount of weight, frequency, twisting)**
vibration	slips and falls	

such as driving heavy equipment and lifting.

3. INJURY AND ILLNESS STATISTICS OF OVEREXERTION IN LIFTING

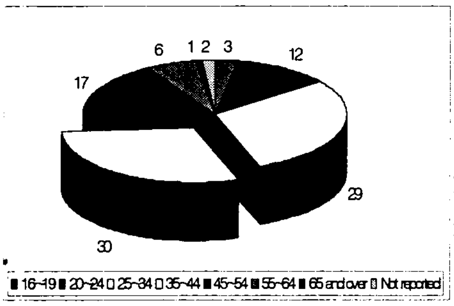
3.1. Body Parts



The [Figure 1] indicates back injuries took account for 64% of overexertion in lifting out of total cases. Therefore, the back was found the most dangerous body part for overexertion in lifting.

[Figure 1] Part of body affected by injury or illness of overexertion in lifting

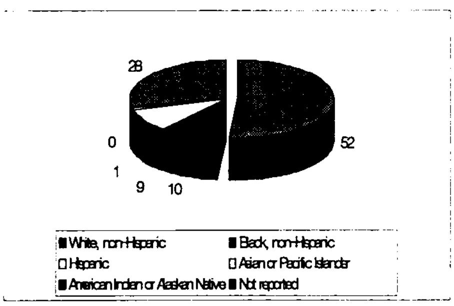
3.2 Age Group



The [Figure 2] shows age group by injury or illness of overexertion in lifting. The major group of injury or illness of overexertion was age of 35-44(30%) and 25-34(29%). That means the groups were the most active group through the labor life.

[Figure 2] Age group by injury or illness of overexertion in lifting

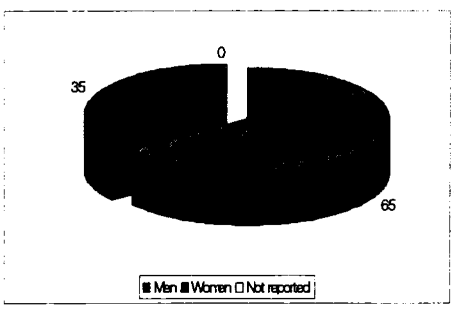
3.3 Race or ethnic origin



The [Figure 3] shows race group by injury or illness of overexertion in lifting. The white, non-hispanic people took account for more than half (52%) out of the total case due to big population in the world.

[Figure 3] Race or ethnic origin by injury and illness of overexertion in lifting

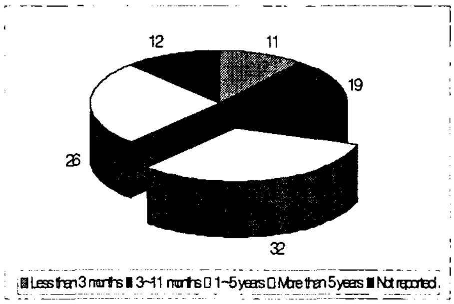
3.4 Sex



The [Figure 4] shows the ratio of male vs female employers of nonfatal occupational injuries and illnesses involving days away from work by overexertion in lifting. The male workers took account for 65% while female 35% for overexertion injuries in lifting.

[Figure 4] Sex by injury or illness of overexertion in lifting

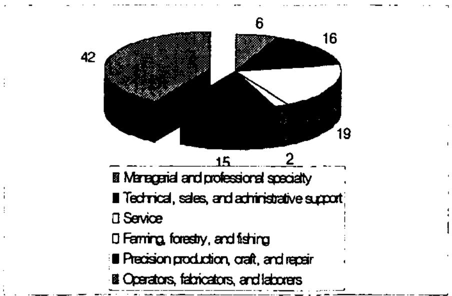
3.5 Length of service with employer



The [Figure 5] shows length of service with employer for nonfatal occupational injuries and illnesses involving days away from work for overexertion in lifting. The major portion of lifting injuries was found the length of 3-5 year employers(32%) and next group was the length of more than 5 year employers(26%)

[Figure 5] The length of service with employer by injury or illness of overexertion in lifting

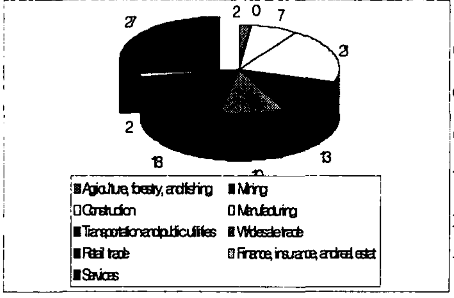
3.6 Occupational groups



The [Figure 6] shows occupational groups by injury or illness of overexertion in lifting. The majority of lifting injuries was found to operators, fabricators and laborers(42%). The portion of injuries for the group took account almost half out of total in injuries of lifting. The second portion of lifting injuries were found to service groups.

[Figure 6] Occupational groups by injury or illness of overexertion in lifting

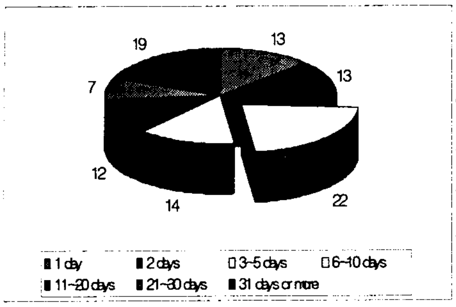
3.7 Industry



The [Figure 7] shows nonfatal occupational injuries and illnesses involving days away from work by industry due to overexertion in lifting. The major portion of the lifting injuries were found in service industry(27%) and second major portion were in manufacturing industry.

[Figure 7] Industry division by injury or illness of overexertion in lifting

3.8 Days away from work



The [Figure 8] shows nonfatal occupational injuries and illnesses involving days away from work by overexertion in lifting. The 3-5 days away from work took account for greatest part of lifting injury(22%) and more than 31 days(19%) were second major portion days away from work by lifting injury.

[Figure 8] Days away from work by injury or illness of overexertion in lifting

4. TRANSLATING A LIFTING BOX

The actual VRML 2.0 code for the world is too long, but a pseudo-VRML listing would be something like this:

```
#VRML V2.0 ut f8
EXTERNPROTO Arithmetic      #full definition omitted
EXTERNPROTO Mapping#full definition omitted
EXTERNPROTO Slider [ eventOut SFFloat fraction_changed
              ] "http://zing.ncsl.nist.gov/~gseidman/vrml/wprotos.wr l#Slider"
EXTERNPROTO Axes [ eventln set_rotation ] "url"
EXTERNPROTO CeteredTextShape [ exposedField MFString string ] "url"
EXTERNPROTO BoxShape [ exposedField SFColor color ] "url"

# the Viewpoint
Transform { translation 10 10 10
        children Viewpoint {        position 0 0 0
                                     orientation -1 1 0 0.78539816 } }

# the box we are moving
DEF MOVER Transform { children BoxShape { color .1 .5 .1 } }

DEF MAPALL Mapping {}
DEF INVERT Arithmatic { coefficient -1 }
```

```
# heads up display
DEF WHERE ProximitySensor { size 10000 10000 10000 }
DEF HUD Transform { translation 0 0 0
children Transform { translation -1.5 -.5 -3
          children [
                   Transform { translation 0 .8 0 scale .3 .3 .3
                             children CenteredTextShape { string "X Y Z" }
                   }
                   DEF AXES {}
                   Transform { translation -.3 0 0
                             children DEF SLIDE1 Slider {} }
                   DEF SLIDE2 Slider {}
                   Transform { translation .3 0 0
                             children DEF SLIDE3 Slider {} }
          ]}
}

#         to keep objects pasted to viewpoint
ROUTE WHERE.position_changed TO HUD.set_translation
ROUTE WHERE.orientation_changed          TO HUD.set_rotation

# invert viewpoint rotation to keep axes in synch with world axes
ROUTE WHERE.orientation_changed          To INVERT.set_rotation
ROUTE INVERT.rotation_result TO AXES.set_rotation

#         combines the three SFFloats into a single SFVec3f translation
ROUTE SLIDE1. fraction_changed           TO MAPALL.set_X
ROUTE SLIDE2. fraction_changed           TO MAPALL.set_Y
ROUTE SLIDE3. fraction_changed           TO MAPALL.set_Z
ROUTE MAPALL.vec3_mapped   .TO MOVER.set_translation
```

5. CONCLUSIONS AND FUTURE RESEARCH

Everyone might have experienced more than one time LBP during one's whole life. The less than 25% of LBP suffers who do not improve spontaneously consume approximately 90% of the total health care resources and associated costs. Average cost per case was $40,000 in the United States. The total cost associated with back problems was $40 billion, and potentially reaching $90 billion annually.

In order to construct VR simulator, a lifting box was translated.

The main cause of LBP was lifting works out of other factors. Considered variables are weight of lift, frequency of lifting, and twisting (0° or 90°). Without optimal lifting works, workers can work safely. Top and middle managers should concern working environment in order to reduce industrial injuries and protect employees from potential hazards. Offering safe working environment is to improve productivity.

REFERENCES

[1] Ayoub, M.A., (1982) "Control of Manual Lifting Hazards: I. Training in Safe Handling", *Journal of Occupational Medicine*, 24(8), pp. 573-577.

[2] Ayoub, M.M. and Mital, A., (1989) *Manual Material Handling*, Taylor and Francis, London.

[3] Ayoub, M.M., Liles, D.H., Asfour, S.S., Bakken, G.M., Selan, J., Mahajan, P., and Bethea, N.J., (1983) "Effects of Task Variables in Lifting Capacity", DHHS(NIOSH), Grant No. 5RO1OH00798-04.

[4] Chaffin, D.B. and Andersson, G.B.J., (1991) *Occupational Biomechanics*, John Wiley & Sons, New York.

[5] Fish, D.R., (1978) "Practical Measurement of Human Postrures and Forces in Lifting. In:Safety in Manual Materials Handling", C.G. Drury(editor), Cincinnati, Ohio: DHEW(NIOSH) Publication No. 78-185, pp. 72-77.

[6] Frymoyer, J.W., Pope, M.H., Clements, J., (1983) "Risk Factors in Low Back Pain", *Journal of Bone and Joint Surgery*, 56-A:pp.213-218.

[7] Jager, M. and Luttmann, A., (1989) "Biomechanical Analysis and Assessment of Lumbar Stress During Load Lifting Using a Dynamic 19-segment Human Model", *Ergonomics*, 32(1), pp. 93-112.

[8] Jomoah, I.M., (1994) "Comprehensive Study of Static and Dynamic Stresses

for Symmetric and Asymmetric Lifting Activities", Ph.D. Dissertation, University of Miami, Coral Gables, Florida.

[9] Khalil, T.M., Abdel-Moty, E.M., Rosomoff, R.S. and Rosomoff, H.L., (1993) *Ergonomics in Back Pain: A Guide to Prevention and Rehabilitation*, Van Nostrand Reinhold, New York, NY.

[10] Kreitle, M., Heim, J. and Smith, R.(1995), "Virtual Environments for Design and Analysis of Production Facilities", *IFIP WG 5.7 Working Conference on Managing Concurrent Manufacturing to Improve Industrial Performance*, Sept., 11-15, Seattle, Washington, U.S.A.

[11] Martin, B.(1996), "Virtual Reality and Simulation", *Proceeding of the 1996 Winter Simulation Conference*, pp. 101-110.

[12] Mital, A., Nicholson, A.S., and Ayoub, M.M., (1993) *A Guide to Manual Materials Handling*, Taylor & Francis, London.

[13] National Institute for Occupational Safety and Health (NIOSH), (1981) *Work Practices Guide for Manual Lifting*, Edited by D.W. Badges, U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health, Division of Biomedical and Behavioral Sciences, Cincinnati, National Institute of Occupational Safety and Health, DHH(NIOSH) Publication No. 81-122.

[14] National Safety Council, *Accident Facts*,

[15] Peter, A., Wolffgang, F. and Stefan, M. (1993), "Virtual Design: A Generic VR System for Industrial Applications", *Computer & Graphics*, 17, pp. 671-677.

[16] Smith, J.L., Smith, L.A. and McLaughlin, T.M., (1982) "A Biomechanical Analysis of Industrial Manual Material Handlers, *Ergonomics*, 25(4), pp. 299-308.

[17] Tichauer, E.A., (1971) "A Pilot Study of the Biomechanics of Lifting in Simulated Industrial Work Situations", *Journal of Safety Research*, 3(3), 98-115.

[18] Webster, B.S. and Snook, S.H., (1991) "The Cost of Compensable Low Back Pain", *Journal of Occupational Medicine*, 32, pp. 13-15.

[19] Yohaman, A. (1997), "Methods Engineering : Using Rapid Prototype and Virtual Reality Techniques", *Human Factors and Ergonomics in Manufacturing*, 7, pp. 79-95.

[20] Superscape 3D Webmaster Tutorials

[21] http://www.cs.brown.edu/~gss/VRML98/paper.rev.html

[22] http://www.cs.jhu.edu/~feldberg/vr/vrbg.html

[23] http://www.mupitt.penza.su/ ~umirs/e_new53.htm
[24] http://www-vrl.umich.edu/imfro.html
[25] http://www-vrl.umich.edu/intro/index.html
[26] http://www-vrl.umich.edu/project/accident/index.html
[27] http://www-vrl.edu/overview.html
[28] http://www.vrt.co.kr

저자소개

김 대 식
1983 명지대학교 공업경영학과 졸업, 공학사
1985 명지대학교 대학원 경영학과(생산관리전공), 경영학 석사
1993 Ohio University, Dept. of Industrial & Systems Engineering(Human Factors Engineering), M.S.
1997 University of Miami, Dept. of Industrial Engineering(Ergonomics), Ph. D. Candidate
현재 안산공과대학 공업경영과 교수
관심분야 Low Back Injuries, Workstation Design, Safety in Virtual Reality, Human Sensibility Ergonomics

강경식
현 명지대학교 산업공학과 정교수.
명지대학교 산업안전센터 소장 및 안전경영과학회 회장
관심분야 생산운영시스템, 시스템 안전