L4/L5 disc compression force in phases of manual human handling

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ABSTRACT

The compression forces on disc of spine were recommended from The National Institute for Occupational Safety and Health (NIOSH). The safety level for disc compression forces during lifting object in manual material handling should less than 3,400 N. There are many studies about disc compression forces in manual material handling, but manual human handling less researched. The aim of this study is to compare L4/L5 compression forces in four manual human lifting techniques and three phases of lifting and transferring. Thirty two subjects lifted a 60±5 kilogram person in four techniques: two-handed seat carry, four-handed seat carry, Fore-and-Aft carry and Chair carry from table height 50 cm walked 9 m, rested 3-5 minutes between each technique. Lifting and transferring was divided 3 phases (origin lift, carry and destination lift). Five cameras were installed in different angle of views to record subject movement during lifting. The static mode of the University of Michigan’s Three-Dimensional Static Strength Prediction Model (3DSSPP) was used to predict lumbar disc compression forces (L4/L5) in each technique during lifting. Only origin lift phase has the average maximum L4/L5 compression forces more than 3,400 N especially Two-handed seat carry and Four-handed seat carry techniques. The results of L4/L5 compression forces of manual human lifting might help to prevent lifters or authorities from back injury.

Keywords: disc compression forces, manual human handling, lifting

1. Introduction

Low back pain were major problem in nurses (Karahan and Bayraktar, 2004) due to awkward postures (Daraiesh et al., 2010) affect to compression forces acting on the spinal discs, especially at L4/L5 or L5/S1. The compression force on disc of spine were recommended from The National Institute of Occupational Safety and Health: NIOSH. The safety level for disc compression force during lifting object in manual material handling should less than 3,400 N (Waters et al., 1993). The techniques for lifting and transferring patient for 2 lifters in emergency situation had several techniques such as Two-handed seat carry, Four-handed seat carry, Fore-and-Aft carry and Chair carry all of them had different lifters postures which made different compression force on spine, too. The purpose of this study was to compare L4/L5 compression forces in the three phases of four manual human lifting techniques.

2. Method

Thirty two healthy men aged 18 to 23 years old and no musculoskeletal problems. The experimental protocol was approved by the Thammasat University Human Research Ethics Sub-committee (Second group) and all volunteers signed consent form prior to data collection. Volunteers lifted a 60±5 kilogram person who was patient with four techniques: Two-handed seat carry, Four-handed seat carry, Fore-and-Aft carry and Chair carry from table height 50 cm (origin lift phase) walked 4.5 m (carry phase) and turned to the origin lift phase volunteers sent the person who was lifted to the receiver at the table was 140 cm. tall with same posture as origin lift phase (destination lift phase) rested 3-5 minutes between each technique. Five cameras (top, front, left, right and back views) were installed in
different angle of views to record subject movement during lifting. Body angles in static posture such as forearm, upper arm, upper leg, lower leg and trunk were captured with skin markers position (38 markers were placed at the anatomical landmarks of volunteers) in horizontal and vertical angle by kinovea program. The static mode of the University of Michigan’s Three-Dimensional Static Strength Prediction Model (3DSSPP) was used to predict lumbar disc compression force (L4/L5) in each technique of three phases during lifting and transferring (origin lift, carry and destination lift). Friedman test and Wilcoxon signed-rank test used with four techniques.

Figure 1. The three phases of lifting and transferring

3. Results

Origin lift phase, all of lifting and transferring techniques (Two-handed seat carry, Four-handed seat carry, Fore-and-Aft carry and Chair carry) had L4/L5 disc compression force more than 3,400 N there were statistical significant difference ($p < 0.001$) in addition Four-handed seat carry technique was highest value (5,338.63 ± 935.96 N) followed by Two-handed seat carry technique (4,559.13 ± 669.11 N) while Two-handed seat carry technique was more than 3,400 N with highest value (3,066.59 ± 491.86 N) in carry phase and all of techniques were statistical significant difference ($p < 0.01$). All of techniques in destination lift phase had L4/L5 disc compression force less than 3,400 N in figure 2.

Figure 2. L4/L5 compression force of four lifting and transferring techniques in three phases (a) origin phase, (b) carry phase and (c) destination phase $p<.05$, $p<.01$, $p<.001$
4. Conclusion

The present study found that L4/L5 disc compression forces during lifting and transferring person weight 60±5 kilogram in two persons lifting techniques of manual human handling exceed NIOSH recommendation (not exceed 3,400 N) especially origin lift phase consistent with the research of K. Davis and W. Marras should be cause the body segments angles of volunteers in vertical of lifters less than other phases, especially trunk (trunk flex angle) it showed that volunteers flexed trunk more than other phases, upper legs and lower legs were slightly angular like in squat posture. The four handed seat carry technique was maximum disc compression force should be cause the volunteers had to hold hands to hand together with each lifter, so the lifters lifted in trunk flex angle less than other techniques. Two-handed seat carry technique had the same reason as Four-handed seat carry technique, but it had trunk flex angle more than Four-handed seat carry technique so made it less L4/L5 disc compression force.

The carry phase Two-handed seat carry technique had the highest L4/L5 disc compression force should be cause trunk flex angle less than other techniques during carrying and walking.

The destination lift phase, it was a period of lifting higher than the shoulder level (140 cm). L4/L5 disc compression force of all techniques were lower than 3,400 N should be cause the volunteers had almost straight back, straight upper leg and lower leg while lifting person to the table.

This study provides evidence about risk to injury while lifting and transferring 60±5 kg person for prevention low back pain especially origin lift phase in two persons lift techniques; two-handed seat carry, four-handed seat carry, Fore-and-Aft carry and chair carry. The ergonomic prevention, such as trunk erect while lifting especially Four-handed seat carry technique and Two-handed seat carry technique in origin lift phase.

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References


