

A Maximum Compression Force Assessment of Two Types of the Stretchers During Moving Patients

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ABSTRACT

Objective: To assess the maximum compression forces of the back while laterally transferring patients from beds to stretchers with different heights of personnel and different types of stretcher.

Methods: The maximum compression forces of the back when moving patients were used to record the movement of subjects by CCTV. SUTStructure Program was used to compute the maximum compression forces of the back. The independent variables, postures, heights of the subject, and type of stretchers were analyzed by SPSS version 13.0.

Results: The maximum compression forces on the back with postural variables were the highest during the curve posture. The height variable revealed that the least maximum forces occurred to the subject with 160-165 centimeters height. Considering the maximum forces occurred at the back, the result showed that the maximum compression forces to move patients with adjustable stretchers could relieve force more than those which occurred with non-adjustable stretchers.

Conclusion: The maximum compression forces of the back while transferring patients with adjustable stretchers was lower than the maximum compression forces with non-adjustable stretchers. Additionally, the height of subjects when transferring patients from beds with 70 centimeters to 70 centimeters and 84 centimeters height of stretchers reveals that patients with 160-165 centimeters height were suitable to transfer from beds to this height of stretchers.

Keywords: Moving patients, lateral transfer, SUTStructure, maximum compression forces.

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INTRODUCTION

Medical personnel have to transfer unconscious and very heavy patients by using only a stretcher and a slide board to reduce friction. In addition, some departments have many instruments such as ceiling lift and hoist to facilitate the process of staff work. However, it is sometimes inconvenient and these instruments are very expensive.¹

The problem commonly occurs when transferring patients which causes lower back pain in staff.² Biomechanical evidence such as shear force, compression force, biological and psychological evidence are considerable

in linking disc compression with vertebral damage for work,¹⁰ and these types of mechanical loading constitute the greatest known risk factors for acute disc prolapse and for lower back pain in general.¹¹ According to data of nursing in Thailand, nurses who move patients in bed without assistance and lack of back muscle exercises, were the significant risk factors which caused lower back pain among nurses.³

Because of staffs' back pain, a stretcher is one of the important factors of injuries to staff who routinely transfer patients in the hospital.⁴ Therefore, stretchers should be developed to support staffs' work during the transfer.⁵ Thus, researchers have decided to assess the lateral transfer using adjustable stretchers which can be adjusted toward up-down directions and to compare with old non-adjustable stretchers in order to examine the compression forces which may occur and whether these adjustable stretchers would reduce the risks and increase the rate of work.

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Therefore, the ergonomic principles especially the compression force assessment of two types of stretchers, i.e. non-adjustable and adjustable stretchers, were examined. The forces of staff injuries, the support of stretchers, and the differences between non-adjustable and adjustable types, were investigated. This study will be beneficial to all medical personnel who are involved in transferring patients.

MATERIALS AND METHODS

This study is conceptualized as a Quasi-Experimental study for assessing the calculation of the maximum compression forces of participants' movements in order to compare these between non-adjustable stretchers and adjustable stretchers. The sample selection in this study is purposive sampling. The samples are staff of Siriraj Hospital who are responsible for transferring patients at OPD of the department of Rehabilitation Medicine. The total number of volunteers in this study was 24: including 16 acting as staff who move patients and 8 acting as patients.

The CCTV system was used to record the information. After that, the data from CCTV were captured and brought to measure the angle of pictures in AutoCAD program. Then the angle of joints were included to calculate the compression forces by the forces and moments at the L5/S1 disc with the function of lifting objects with the Biomechanical model of static condition with the Chaffin and Anderson model applied to use in the SUTStructure program while moving patients with both types of stretchers, different heights of staff and postures. The posture variables including upright, middle, and curved postures, and staffs' heights varied from 160-165, 166-170, 171-175 centimeter heights and mixed heights. Staffs' height variables varied from 160-165, 166-170, 171-175 centimeter heights including upright, middle, and curve postures. Subject groups were transferred from a 70 centimeter-height patient's bed to 84 centimeter-height non-adjustable stretchers and 70-centimeter-height adjustable stretchers. The study was approved by the Committee on Human Rights Related to Siriraj Institutional Review Board, Faculty of Medicine, Mahidol University, Bangkok, on June 22, 2011 Project No. Si 341/2011.

The materials used in this study consisted of a tilt adjustable stretcher as a table for this study, and up-down direction was used. Its dimensions were 68 × 197 × (high 99, low 63) centimeters. A non-adjustable stretcher was used for transferring patients in Siriraj Hospital with dimensions 80 × 185 × 84 centimeters. The patient's bed which was used to transfer patients was non-adjustable and 70 centimeters height for this study. A plastic slide board, which was smooth and elastic, was used to relieve crash and friction while moving patients. Video recording of transferring procedures was done by using CCTV (four cameras) with Camera Resolution 480 lines (pixels) and 25 frames per second. Anthropometer is a tool to measure the body dimensions of subjects and was used for calculation in SUTStructure program. SUTStructure program is a gratis tool to calculate the compressive forces designed

by Suranaree University of Technology with Suranaree University of Technology Structural Mentor version 3.50.

Subject selection

According to OPD and the Department of Rehabilitation Medicine, Siriraj Hospital (2009), the population of staff who are responsible for transferring patients are 157 staff.

Definitions

Maximum of compression forces in this study was the summation of tensile force of Extensor erector spinae (It has to resist the moment at the L5/S1 disc and make a balance between force and body) and the compression force of the back at the L5/S1 disc.

Upright posture meant standing position and ready to lift the patient from the bed.

Middle posture meant standing position and lifting while the heads of patients were above the center of the junction between bed and stretchers.

Curve posture meant standing position and lifting the patient to the center of the stretcher.

The statistics analysis

SPSS version 13.0 was used to analyze the data as follows:

Inferential Statistics

1 The Wilcoxon's signed rank test was used to analyze the difference of the maximum compression forces between non-adjustable and adjustable stretchers.

2 The Kruskal – Wallis test was used to analyze the difference of the maximum compression forces that were used to move patients and the difference of posture and heights of patients.

The p-value of ≤ 0.05 was considered statistically significant.

RESULTS

Maximum compression force: Posture variable

Table 1 showed that the maximum compression forces which occurred at the back when moving the patients with both stretchers in Upright and Curve posture was statistically significantly different with p-value <0.005, while those which occurred in middle posture were not statistically significantly different (p-value 0.419). The maximum compression forces were lesser when using



Fig 1. Postures for moving patient from bed to adjustable stretcher.



Fig 2. Postures for moving patient from bed to non-adjustable stretcher.

adjustable stretchers compared to non-adjustable stretchers especially in curve posture.

When compared within each type of stretcher, the maximum compression forces which occurred at the back, when moving the patients with both non-adjustable and adjustable stretchers in Upright, Middle and Curve posture, were statistically and significantly different with p -value <0.001 . The maximum compression forces increased from upright to middle and was maximal at curve posture which were similar in both types of stretcher.

Height variable

Table 2 has shown that the maximum compression forces occurred at the back when moving the patients with both types of stretchers of subjects with different heights. The force of moving subjects with 160-165 and 171-175 centimeter heights were statistically significantly different with p -value <0.05 , while those of the subjects with 166-170 centimeter height was not statistically significantly different (p -value 0.369).

When force within each type of stretcher was compared, the maximum compression forces which occurred at the back, when moving the patients with non-adjustable stretcher, of the patients with different heights of 160-165, 166-170 and 171-175 centimeters, was not statistically significantly different with p -value 0.132. In comparison the results of the maximum compression forces which occurred at the back, when moving the patients with adjustable stretcher, of the patients with 160-165, 166-170 and 171-175 centimeter heights, was statistically significantly different with p -value 0.006. The maximum compression force increased according to patient's height. The more height of patients, the more the maximum compression force was with the adjustable stretcher.

TABLE 1. The maximum of compression forces (N) and different stretchers at back with different postures.

Posture	Maximum Compression force at Back		p-value1*
	Mean ± SD		
	Median (Min, Max): n=128		
	Non-adjustable stretcher	Adjustable stretcher	
	Height 84 cm.	Height 70 cm.	
Upright	2362.2±1268.8	2420.8±781.0	0.005
	2137.5 (97.5,9300.0)	2277.6 (661.0,5270.0)	
Middle	4391.5±1103.2	4347.2±1102.3	0.419
	4361.0 (467.2,7690.4)	4312.0 (1960.1,7553.2)	
Curve	6738.4±1259.1	6486.8±1289.5	<0.001
	6819.0 (2070.4,10411.0)	6687.8 (1044.2,8788.6)	
p-value 2**	<0.001	<0.001	

* p-value 1, Compared between adjustable and non adjustable stretcher

** p-value 2, Compared between difference posture of each stretcher

n=128, number of event in transferring patients

TABLE 2. The maximum of compression forces (N) and different stretchers at back with different heights.

Height of subject (cm)	Maximum Compression force at Back		p-value1*
	Mean ± SD		
	Median (Min, Max) : n=96		
	Non adjustable stretcher	Adjustable stretcher	
	Height 84 cm.	Height 70 cm.	
160-165	4288.8±2186.3	4019.3±1893.9	
	4343.5 (359.0,10411.0)	3982.9 (661.0,7561.9)	<0.001
166-170	4936.3±2173.1	4796.8±2110.8	
	4749.4 (1597.3,9387.5)	4924.0 (1491.7,8788.6)	0.369
171-175	4638.8±2160.7	4817.2±2036.3	
	4405.6 (1493.6,9300.0)	4465.7 (862.6,8463.2)	0.035
p-value 3***	0.132	0.006	

* p-value 1, Compared between adjustable and non adjustable stretcher

*** p-value 3, Compared between difference height of each stretcher

n=96, number of event in transferring patients

DISCUSSION

When forces which occurred between each type of stretcher, were compared, we found that postures affect compressive forces at the back during the transfer. Forces which occurred during curve posture caused maximal compressive force more than middle and upright postures. The maximum compression forces to move patients with upright posture with non-adjustable stretchers were less than adjustable stretchers because the start positions to lift subjects with non-adjustable stretchers were closer to the body than lifting subjects with adjustable stretchers and the height of adjustable stretchers was lower than non-adjustable stretchers. In addition, subjects bend their bodies more in adjustable stretchers than those in non-adjustable stretchers.⁶ On the contrary, the result of maximum compression forces to move patients in curve posture with adjustable stretchers were less than non-adjustable stretchers. However, the maximum compression forces to move patients with curve posture, was more than the forces to move patients with upright posture. The reason may be that a patient's back is dimensionally long and perpendicular to the nurses' spines.^{7,8} For middle posture, the result of compression forces was no different.

These results referred to middle posture and curve posture which can relieve some of the maximum compression forces, but there were still risks of back injury and these postures can cause injuries more than upright posture. Thus, moving patients with adjustable stretchers can relieve the forces and can prevent back injury. These situations happened when using both adjustable and non-adjustable stretchers. This study confirms that, when transferring patients from beds to stretchers, curve posture creates the maximal force when compared to other postures and using adjustable stretchers is better than non-adjustable stretchers. Therefore, medical personnel should pay attention during patient transfers for safety.

When considering the height of personnel, height affects only when using adjustable stretchers. The more height of staff, the more compressive forces occurred at the back. Forces which occurred in staff with 166-170 centimeters height were not different among both types of stretchers. Comparing between types of stretchers, compressive forces which occurred with curve posture in adjustable stretchers was less than those in non-adjustable stretchers. In addition, the compressive forces which occurred when using adjustable stretchers in staff whose height ranged from 160-170 centimeters caused less force than using non-adjustable stretchers. These results confirmed the benefit of adjustable stretchers over non-adjustable stretchers due to less compressive forces of adjustable stretchers in curve posture and suitable height of personnel of 160-170 centimeters. In addition, the study revealed that the increasing trend of maximum compression forces with difference staff heights means the height of personnel and the height of stretchers had the effect from the compression forces. The results are relevant for attention about the relational height of subject and stretchers. Further study should perform the assessment of the compression forces or the biomechanics forces to

determine the suitable height of personnel and the height of stretchers to transfer patients from beds to non-adjustable and adjustable stretchers.

Also the height of staff revealed that when subjects with 160-165 centimeters heights moved patients with adjustable stretchers, they can relieve the maximum compression forces on their backs because the dimensions of knuckle-height and elbow-height of personnel were closer to the height of stretchers.

The injuries of back muscle, broken vertebral column, and intervertebral disc prolapse from maximum compression forces might occur more frequently when staff moved patients with non-adjustable than with adjustable stretchers.⁹ With an adjustable stretcher, there was a trend to relieve the maximum compression forces at the back, but it was not safe except moving patients with both stretchers in upright posture which used the least exertion and it was not harmful to the back.

We can apply these results to transfer patients in the hospital by selecting staff to move patients when we use non-adjustable stretchers. We should select the staff with similar height to lift and transfer patients. Also, we should select either adjustable stretchers or adjustable beds to transfer patients from beds to stretchers or from stretchers to beds to relieve the compression forces of the back and to prevent the injury of back muscle and vertebral column.

CONCLUSION

The maximum compression forces have an increasing trend from upright, middle to curve postures. When considering the compression forces which occurred to the back only, the results showed that the maximum compression forces to move patients with adjustable stretchers, were less than those which occurred with non-adjustable stretchers. The suitable height of staff for adjustable stretchers (70-84 centimeter heights.) was 160-165 centimeters.

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