ABSTRACT

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Body mechanic checklist scores, thigh, trunk, and center of gravity displacement during a one person pivot transfer, and boosting up in bed were evaluated to determine the effectiveness of job specific training on the work performance of female student nurses from a local college. Thirty female S's participated in the study and were divided into a control group, an experimental group that received basic body mechanic training, and an experimental group that received job specific training. Results of the body mechanic checklist analysis indicated that the job specific training group demonstrated a statistically significant improvement in their body mechanic techniques compared to the other two groups. Results of the kinematic analysis found no significant differences in thigh and trunk displacement during the one person pivot transfer between the three groups. Results of the thigh, trunk, and horizontal center of gravity displacement during boosting a patient up in bed indicated that the job specific training group improved their body mechanic techniques compared to the other two groups.

THE EFFECTIVENESS OF JOB SPECIFIC TRAINING ON THE WORK PERFORMANCE OF FEMALE STUDENT NURSES

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CHAPTER 1

INTRODUCTION

Background

Low back pain is one of the most frequently occurring occupational injuries. Morris (1984) estimated that 8 out of 10 people will experience low back pain to a significant degree in their lifetime. The high prevalence of back injuries has been of great concern to the medical community and the workplace. Webster and Snook (1990) estimated that 11.1 billion dollars were spent in 1986 on medical care and on lost wage compensation for workers with low back injuries. There has been an increased emphasis on injury prevention within the workplace in an attempt to decrease medical costs and reduce human suffering related to back pain. Carlton (1987) stated:

> It would seem that the knowledge base and functional approach of the occupational therapist can be used by industry and self insured companies as a means of increasing worker safety through instruction in and application of body mechanic techniques necessary for safe lifting and lowering. (p. 16)

One occupation that has been identified as having a high risk of back injury is the nursing profession (Magora, 1970). This profession involves frequent lifting and handling of patients. These patients often require complete assistance to move. It appears that an injury prevention program for this profession may be useful in decreasing the number of injuries occurring in this occupation. The recommended content of such an injury prevention program varies among the experts. It was recommended by Carlton (1987) and Dembert (1990) that injury prevention programs should include a review of back anatomy, causes of back injuries, and instruction in proper body mechanic techniques. Melton (1983) and Nachemson (1975) indicated that body mechanic training should be job specific.

Purpose

The purpose of this study was to determine if student nurses who received job specific training (JST) used better body mechanics during simulated job tasks than those student nurses that received basic body mechanic training (BBMT), or those student nurses that received no training at all. Body mechanics were evaluated with two measuring tools. The first tool was a body mechanic checklist that evaluated key components of the simulated work tasks. The second measuring tool evaluated the angular kinematics of each subject's thigh and trunk during the simulated work tasks.

Need for the Study

Nursing has been identified as a high risk occupation for back injuries. Chaffin, Herrin, Keyserling, and Garg (1977) reported that "there is little doubt that lifting moderate to heavy loads can create excessive mechanical stresses on various components of the musculoskeletal system" (p. 662). This can lead to back injuries resulting from lifting. Ekholm, Arborelius, and Nemeth (1982) reported that a person lifting even light to moderate weight with a poor lifting technique can reach or exceed the tolerance limit for compressive stress of the lumbar disc and cause damage to the spine. Safe lifting tolerances are discussed further in the review of related literature.

Injury prevention programs have been recommended by Carlton (1987), Linton and Kamwendo (1987), and Melton (1983) as an effective method to decrease injuries. Prevention programs do incur a cost that needs to be justified. The most effective contents of educational prevention programs were not clear in the literature. This needs to be identified in order to provide cost-effective prevention programs for nursing personnel. One drawback to a JST program is the time requirement to complete the program. However, if JST is more effective than the BBMT, the extra time and cost would be justified. An effective injury prevention program would reduce the risk of back injuries, and decrease the amount of human suffering that occurs with back injuries. It would also decrease the amount of time employees are away from their jobs and the amount of money employers spend on worker's compensation.

Hypothesis

There will be a significant difference in student nurses' body mechanic techniques who received JST when compared to those student nurses who received BBMT, or no training at all. The following questions were investigated:

1. Is there a significant difference between the body mechanic scores for the one person pivot transfer among the three groups?
2. Is there a significant difference between the body mechanic scores for boosting a patient up in bed among the three groups?
3. Is there a significant difference in the angular kinematics among the three subject groups?

Assumptions

The following assumptions were made:

1. Knowledge regarding proper body mechanics for nursing tasks was minimal as the subjects were student nurses and had not yet been instructed in these techniques during their professional preparation. The students may have had some exposure to body mechanic techniques during previous jobs. However, as the subjects were randomly assigned into the experimental and control groups, prior knowledge of body mechanic principles was assumed to be equally distributed among the groups.

2. Any comparison made among the three groups after the experimental treatment would be due to the type of training the subjects received.
3. All subjects had sufficient physical strength to complete the simulated work tasks.
4. Subjects in the experimental groups did not communicate with each other or the control group with regards to educational information.
5. The occupational therapist providing the experimental treatment had adequate knowledge of proper body mechanic techniques for nursing tasks and was competent in instructing the student nurses.
6. The student nurses possessed the ability to comprehend the instruction they received.
7. The body mechanic checklist was a valid instrument to evaluate key components of a one person pivot transfer and boosting a patient up in bed.
8. Dehlin, Berg, Andersson, and Grimby (1981) reported that nursing aides with low back symptoms were found to have a more negative attitude toward work than those nursing aides without back problems. It was further assumed that because the experimental and control groups were student nurses, that job dissatisfaction would not be an issue.

9. The volunteer patient that assisted with the simulated work tasks was instructed to require minimal assistance during these tasks. It was therefore assumed that the patient completed 75% of the physical effort required to move his body and the subject provided 25% of the assistance.

Delimitations

This study had the following delimitations:

1. This study was conducted with female student nurses from a local college.
2. All of the educational training was completed by the same registered occupational therapist.
3. Work performance, as evaluated with the body mechanic evaluation checklist, was completed by three occupational therapists, the therapist completing the training and two additional occupational therapists who were thoroughly instructed in the use of the body mechanic evaluation checklist prior to use.
4. Job specific body mechanic instruction was limited to the one person pivot transfer and boosting a patient up in bed.
5. This study did not attempt to determine the body mechanic knowledge that the subjects possessed prior to the study.

6. Student nurses with a previous history of low back injuries were excluded from the study.
7. The volunteer patient required only minimal assistance to complete activities, therefore, requiring the least amount of physical exertion possible for the subjects.

Limitations

This study had the following limitations:

1. The study was conducted with female student nurses, therefore, results may not apply to other types of occupations, workers, or male nurses.
2. The training was completed by an occupational therapist, therefore, results may not apply to programs that are completed by other professionals.
3. The volunteer patient required minimal assistance to complete the simulated job tasks, therefore, results of this study may not accurately reflect body mechanic techniques used with patients requiring total assistance and more force to move.

Definition of Terms

Frequently used terms were defined as follows:

Absolute Angle - the angle of the joint as it relates to a horizontal or vertical plane.

Body Mechanics - the efficient use of the body that facilitates the lessening or elimination of physical strain that may cause injury.

Kyphotic Lumbar Curve - convex curvature in the lumbar portion of the vertebral column.

Lordotic Lumbar Curve - concave curvature in the lumbar portion of the vertebral column.

Minimal Assistance - the volunteer patient completed 75% of the physical body movement and required 25% assistance from an outside source. The volunteer patient was fit with a full leg brace and was not allowed to bear weight on this extremity.

Proper Body Mechanics - for the purpose of this study, proper body mechanics were defined as lifting with leg muscles, maintaining a wide base of support, maintaining back curves, keeping the weight close to the body, and avoiding twisting.

Relative Angle - the angle of a joint between two segments.

Simulated Work Tasks - those activities that as realistically as possible represented work tasks completed daily by a nurse. The work tasks used in this study were:

1. one person pivot transfer from a bed to a chair.
2. boosting a volunteer patient up in bed.

Volunteer Patient - a healthy individual, instructed to act as a patient.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The literature review establishes the prevalence and cost of back injuries in the general population and nursing personnel. The common causes of back injuries and possible methods of prevention will be reviewed. Kinematic and kinetic studies of lifting, including such factors as the importance of lifting analysis, joint angles, angular acceleration, center of gravity (COG), skilled versus unskilled lifters, loading moment, force, torque, and muscle activity during lifting will also be reviewed.

Prevalence of Back Injuries

Low back pain is one of the most frequent and disabling injuries occurring in the general population (Andersson, 1981; Bettencourt, Carlstrom, Hargreaves-Brown, Lindau, & Long, 1986; Chapman, 1984; Kelsey & White, 1980; Magora, 1970). "Second only to the common cold, back pain is the most common aggravation the United States population incurs" (Melton, 1983, p. 20). Many authors (Anderson, 1980; Bergquist-Ullman, & Larsson, 1977; Nachemson, 1966) stated low back pain has become an important problem in today's society and is chiefly responsible for absence, job change, and early retirement among the working population. Kelsey and White (1980) reported that 40% of all work place absences were due to back problems. Four out of five adults at some point in their lives experience back pain (Shotkin, Bolt, & Norton, 1987). It was estimated by Morris (1984) that "80% of the general population will experience low back pain of a significant degree in their lifetime" (p. 44). In a study completed by Frymoyer et al. (1983), 70% of the general population experienced moderate to severe low back pain. Cust, Pearson, and Mair (1972), Magora (1970), and Videman et al. (1984) reported the prevalence of low back pain in nursing personnel is high. Cust and associates (1972) stated that "low back pain is thought to be a particular hazard of nursing" (p. 51). Dehlin, Hedenrud, and Horal (1976) found 47% of nursing aides had experienced low back pain on some occasion. It was noted by Raistrick (1981) that 41% of nurses indicated the cause of their back pain was from lifting at work. Videman et al. (1984) found that 79% of nurses and 85% of nursing aides had experienced at least one episode of low back pain. The trend for earlier episodes of low back pain is prominent in nurses.

Cost of Back Injuries

The cost of low back pain is expensive for the employer and the employee. This cost is rising at a faster rate than any other type of work related injury. It was estimated that the total compensable cost for 1986 low back pain cases in the United States was $11.1 billion. This was a 241% increase over the 1980 estimate of $4.6 billion dollars reported by the Liberty Mutual Insurance Company (Webster & Snook, 1990).

A 1984 survey completed for the American Academy of Orthopedic Surgeons found that the total annual cost for back injuries was almost $16 billion. Inpatient services represented the largest portion of direct costs (Snook, 1988). The high cost of low back injuries was also reported by several other authors (Bettencourt et al., 1986; Caruso, Chan, & Chan, 1987; McElligott, Miscovich, & Fielding, 1989; Wick, 1989).

Not only are the medical costs of back injuries high, but the chances of these employees returning to work after an injury decreases with time. McGill (1968) reported:

> Records indicate that workers with back complaints who are off work over six months have only a 50% possibility of ever returning to productive employment. If they are off work over one year this possibility drops to 25% and if more than two years it is almost nil. (p. 174)

For nurses, back pain is not only expensive, but for some nurses it can mean the loss of their livelihood (Raistrick, 1981). Anderson (1980) stated that prolonged or repeated absence from a job can force the injured employee to take a less physically demanding job in the same industry.

Causes of Back Injuries

The following activities have been identified as potential causes of back injuries: heavy work, twisting, lifting weight while in a stooped position, bending, sudden maximum effort, prolonged postures, repetitive work, carrying, push/pulling, sitting or standing for prolonged periods of time, and holding an object too far away from the body (Anderson, 1980; Andersson, 1981; Biering-Sorensen, 1983; Bergquist-Ullman & Larsson, 1977; Chaffin & Park, 1974; Frymoyer et al., 1983; Frymoyer et al., 1980; Kelsey, 1975; Kelsey & White, 1980; Kroemer, 1980; Magora, 1972, 1973; McGill & Norman, 1986; Nachemson, 1975; Troup, 1984). Improper body mechanic techniques were identified by Bettencourt et al.(1986) as a major cause of back injuries. Lloyd and Troup (1983) reported that 49% of back injured patients reported another episode of back pain one year after the initial back injury. Biering-Sorensen (1983) also stated that a person with a previous back injury will be more likely to experience another within the same year.

Frymoyer et al. (1980, 1983) reported that people with low back pain were more likely to be cigarette smokers. Age was not a factor in the cause of low back pain according to McGill (1968). Kelsey (1975) found no correlation between the body weight or size of people with back injuries. Andersson (1981) and Chaffin and Park (1974) supported these findings by stating there was no correlation between weight, stature, and body build and the incidence of low back pain. Height and weight were not significant factors of low back pain with nurses in a study completed by Raistrick (1981).

Andersson (1981) found that gender factors were not important with respect to low back symptoms. Frymoyer et al. (1980) also stated that all the risk factors identified for men were also present for women. Biering-Sorensen (1983) found that men generally experienced their first episode of low back pain before the age of 31. However, Biering-Sorensen stated that this may be due to older men forgetting the exact occurrence of their first episode of low back pain, as a long time may have elapsed since this experience. Women tended to have a prevalence of back pain at the age of 51-61, but postmenopausal osteoporosis may be partly responsible for this (Biering-Sorensen, 1983). Menopause did not seem to be a significant factor for women in the nursing profession, as Magora (1970) found that nurses typically experienced back pain earlier than the general population. In the nursing profession, prevalence of low back pain was generally reported only for women. Cust et al. (1972) reported "the number of male nurses was too small to enable estimates of prevalence to be made" (p. 170).

In the nursing population, lifting was reported to be the major cause of injury (Cust et al., 1972; Daniel, Fairbank, Vale, & O'Brien, 1980; Magora, 1970; Videman et al., 1984). The working environment for nurses involves physical stress caused by lifting heavy patients. The load during patient handling often exceeded the maximum recommended values (Dehlin et al., 1981). Videman et al. (1984) stated "the mechanical stress and energy cost of patient handling are very much greater than those that arise in most industries" (p. 400). Nurses on the average lift 32.7 kg. during a single lift. This is twice the International Labor Organization's recommendations of 15-20 kg. for females over the age of 18. These weights are handled by many nurses every day (Raistrick, 1981). The National Institute for Occupational Safety and Health (NIOSH) recommended an average female completing manual material handling in industry lift from thigh height to thigh height - 24.9 kg.; thigh height to chest height - 22.7 kg.; and from thigh height to above shoulder height - 20.4 kg. NIOSH defined thigh height as having subject's hands positioned above the knees and below the hips; chest height - hands are positioned above the hips and below the shoulders; and above shoulder height - hands are positioned above the shoulders (Keyserling, 1989).

In addition to the above stated risk factors for low back injuries, Dehlin and Berg (1977) reported nursing aides with low back symptoms were found to have a less positive attitude towards work than those nursing aides without back problems. The geriatric patient population was identified as the area where the largest number of nurses experienced their first occupational back injury (Cust et al., 1972). Working with the geriatric population often involves heavy lifting of patients.

Prevention Programs

Many health care workers have documented the need for injury prevention programs. Carlton (1987) stated that since occupational back injuries are one of the most frequently disabling and costly work related injuries, it is necessary to prevent as many of these injuries as possible. Body mechanic instruction is one way to educate workers in the effective use of the human body in the performance of work activities.

The current trend for dealing with low back problems is increased emphasis on prevention of low back pain (Linton & Kamwendo, 1987). Melton (1983) stated that "in recent years

the emergence of the concept of educating individuals to take responsibility for their own health has offered some hope" (p. 20). Dwyer (1987) reported that although the natural aging process cannot be changed, the aggravating factors can be. This author suggested that the public be instructed in proper body mechanics techniques for home and work activities and this training begin in school and reinforced by the media and educational classes.
The need for injury prevention programs through body mechanic training has also been supported by numerous other health care workers (Bergquist-Ullman & Larsson, 1977; Ferguson, 1984; Magora, 1972, 1973; McCauley, 1990).

The federal government also found additional control over workplace hazards was necessary. In 1970, the Federal Occupational Safety and Health Act was passed. It recognized the need for workers to change how they completed work tasks to aid in preventing injuries (Vojtecky, 1988).

The cost of injury prevention programs is of concern to many companies, however the cost of these programs is usually less than the amount of money spent on treating back injuries. Troup (1984) stated that injury prevention programs do incur a cost that has to be weighed against the overall cost of both the injuries themselves and the losses in productivity which occur from the back injuries. Troup

(1984) went on to say that the cost of injury prevention programs was more than justified on financial grounds. Snook (1988) supported Troup (1984) by stating that although control measures can be costly they are usually less costly than paying for back injuries.

Implementing an injury prevention program can be cost effective and profitable for companies. If a $6,000 prevention program prevents one case of low back pain it has paid for itself within a year (Webster & Snook, 1990). Injury prevention programs as a cost effective way of decreasing back injuries were also supported by Kelsey and White (1980) and Morris (1984).

Even though the effectiveness of injury prevention programs has been supported by health care professionals, little has been done to implement these programs. Melton (1983) reported workers have received little information on how to prevent back injuries. In addition, there is little information on how body mechanic training should be conducted (Troup, 1984). Several authors suggested training be provided to employees with high risk jobs and should focus on lifting techniques (Anderson, 1980; Daniel et al., 1980; McCauley, 1990).

Educational Programs

The educational programs recommended by health care professionals are of two types. The first type of program outlined basic instruction of back injury prevention techniques. The second type suggested body mechanics specific to the worker's job. Occupational therapists were identified as the profession to provide this training (Carlton, 1987; Caruso & Chan, 1986; Caruso et al., 1987; McCauley, 1990).

The first type of program (basic body mechanic training) consisted of review of back anatomy, functions of the back, common causes of back injuries and proper body mechanic techniques (Carlton, 1987; Dembert, 1990; Flower, Naxon, Jones, & Mooney, 1981; Gates, 1986; McElligott et al., 1989; Nachemson, 1975; Selby, 1982; Shotkin et al., 1987; Troup, 1984; Wick, 1989). Proper body mechanics as defined by Melton (1983), Nachemson (1975), and Troup (1984) included lifting with knees flexed with the spine as straight as possible, holding weight close to the body, avoiding twisting and bending, and maintaining a wide base of support.

The second type of injury prevention program identified by health care professionals was job specific training (JST). Supporters of JST stated that the first type of injury prevention program consisting of basic body mechanic principles was not sufficient to change employee's work habits as the program was not specific to work tasks (Bergquist-Ullman & Larsson, 1977; Bettencourt et al., 1986; Cairns, Thomas, Mooney, & Pace, 1976; Caruso & Chan, 1986; Caruso et al., 1987; Nachemson, 1975; Newman, Seres, Yospe, & Garlingon, 1978; Van Oort, Fredrick, Pinto, & Ragone, 1990). Melton (1983) stated:

> Prevention and control of back injuries through education and training can be successfully accomplished if the program materials are customized for the person on the job. The program must be relative to the individual and what he is doing. The concepts of proper body mechanics must be emphasized with a degree of flexibility to accommodate each individual method of working. (p. 23)

Anderson (1980), Dwyer (1987), and Morris (1984) also emphasized that body mechanic training should focus on job tasks. It was suggested by McCauley (1990) and Troup (1984) that body mechanic training should be completed at the work site.

<u>Basic Body Mechanics Versus Job Specific Training</u>

Carlton (1987) completed a study to examine the effectiveness of instruction in body mechanics for lifting and the use of these techniques in the work environment. Thirty-six food service employees at a small liberal arts university participated in this study. Carlton utilized a 17 point criterion referenced evaluation checklist to evaluate the subjects body mechanics during lifting tasks.

Carlton found there was no significant difference in work performance among the group that received body mechanic training and the group that did not. The body mechanic training received by the experimental group did not take place at the work site and was not job specific. This may in part account for the results of the study. Carlton did suggest further study to provide job specific body mechanic training in the work environment.

Dehlin et al. (1981) completed a study to determine if body mechanic training had a positive influence on the psychological perception of work and reduction of low back symptoms on a group of nursing aides. The authors found no evidence that body mechanic training influenced the psychological perception of work or reduced low back symptoms. The body mechanic training provided to the subjects was not job specific. In addition, the subjects were not tested on their comprehension of the material and an assessment of job performance was not completed after the training to determine if body mechanic techniques had changed in response to the training.

Effects of JST on the work performance of 30 newly employed young workers, working as custodial helpers and grounds keepers assistants was addressed by McCauley (1990). The author utilized a 20 point body mechanic checklist to evaluate body mechanic techniques of the subjects during lifting tasks. McCauley found that subjects who received JST performed better at work than those workers who received no training. The subjects in this study were in the 14-19 age group. The results of this study may not apply to the general population of workers as the subjects were younger than the general working population. The body mechanic training and evaluation occurred within one month. McCauley stated no follow-up study was conducted to determine the long term effects of body mechanic instruction. McCauley suggested a longer observation period to determine long term carry over of body mechanic techniques.

Styles of Lifting

A review of the literature indicated that there are three different lifting styles. They are: (1) vertical trunk with flexed knee position with lumbar spine in a kyphotic position, (2) inclined trunk with flexed knee position with lumbar spine in a lordotic position, and (3) back bent and knees straight - stooped lift. There was a general consensus that lifting with the legs is less stressful than lifting in the stooped position. When lifting in the erect position, most of the weight is transferred to the upper part of the vertebral column. In the stooped position the weight is transferred to the thoracic and lumbar vertebrae and to the pelvis (Davis, 1959).

Health care professionals also tended to support lifting with the lumbar spine in a lordotic position versus a kyphotic position. Holmes, Damaser, and Lehman (1992) investigated the differences between squat-lifts from the kyphotic and lordotic lumbar postures. They concluded that the lordotic position was the better position to provide force from the erector spinae muscles during lifting. Twelve subjects were videotaped lifting from both kyphotic and lordotic positions. The authors used the recorded kinematics to determine the torque at the lumbar spine. They then compared these torques to electromyographic (EMG) data recorded during the lifts to determine when muscle activity generated the force. The authors found significant differences in L3 angular excursions between the two lifting postures. The L3 angle in the lumbar spine increased by 35-60 degrees in the kyphotic position. Total torques at L3 were similar between the lordotic and kyphotic positions, but because the angles were different, the torque experienced by the spine was also different. The largest torques at the L3 vertebrae were experienced in the kyphotic position.

Holmes et al. (1992) also reported that the EMG results were different between the lordotic and kyphotic postures. The erector spinae muscles were active to the largest degree in the beginning of the lordotic position lift and smallest at the beginning of the kyphotic position lift. The authors stated:

> Because there is very little erector spinae activity at the beginning of kyphotic lifts, the highest torques about L3 can only be countered by passive restraints of structures supporting the highly flexed spine. The erector spinae are active from the beginning of the lordotic lift, so active muscles bear some of the load created by the earlier torques. (p. 330)

Several health care professionals supported the conclusion made by Holmes et al. (1992). Delitto, Rose, and Apts (1987) reported that when the lumbar curve was maintained in lordosis, there was less stretch on the posterior elements of the lumbar spine. This decreased the stress placed on the lumbar spine. Sedgwick, Gormley, and Smith (1989) also indicated that lifting with the lumbar spine in lordosis was a safer lift, as the integrated action of the trunk, hip, knee, and ankle joint muscle complex ensured the sharing of the lifting stresses rather than their concentration on one complex. The isometric action of the extensor muscles also provided adequate protection to the lumbar spine. Delitto et al. (1987) also reported that the muscle recruitment pattern of the lordotic lifting position provided the best support and protection to the lumbar spine during lifting. Aspden (1989) also supported maintaining the lumbar spine in lordosis when lifting.

Kinematic Studies

Importance of Lifting Analysis

The high incidence of low back injuries related to lifting activities has focused interest on the stresses on the trunk, particularly the spine. Much attention has been given to the technique of lifting as a means of decreasing the stress on the spine (Andersson, Herberts, & Ortengren, 1983; Andersson, Ortengren, & Nachemson, 1976). The science of biomechanics has provided the means to measure and quantify the stresses involved in lifting. A kinematic analysis of lifting can play an important role in determining the amount of stress on the musculoskeletal system. Kinematic analysis is also necessary to develop data on angular displacement, total displacement at the joint, and velocity and acceleration profiles. Once these factors are known, the injuries caused by lifting can be identified and decreased (Ayoub, Dryden, & McDaniel, 1974).

Joint Angles

Brown and Abani (1985) analyzed body segment orientations, vertical bar accelerations, vertical point reaction forces, and segmental angular accelerations for weightlifters completing the dead lift. The absolute angles of the shank, thigh, and trunk were determined relative to the horizontal. The posterior knee angle, formed by the shank and thigh, and the anterior hip angle, formed by the thigh and trunk were also calculated. The authors found during the early part of the lift, the trunk angle decreased, while the knee angle increased. This indicated a dominance of knee extension over hip extension. At the completion of the lift, the angles of the shank, thigh, and trunk approached 90 degrees, while the hip and knee approached 180 degrees.

Hay, Andrews, Vaughan, and Ueya (1983) completed a study to determine what effects variations in the external load had on the joint torques exerted at the hip, knee, and ankle joints during the performance of a squat lift. Three adult male weightlifters were used in this study. Their results indicated that as the external load was increased, there was a progressive increase in the inclination of the trunk at the start of the lifting phase. This increase in trunk inclination - lowering the trunk towards the horizontal meant that the hip extensors assumed more of the increased load and the knee extensors less. Andersson et al. (1976) supported the findings of Hay et al. (1983) by stating that as heavier weights were lifted, the angle of forward flexion of the trunk increased.

Davis, Troup, and Burnard (1965) completed a study in which subjects lifted a box containing weights up to 40 kg. from the floor to waist level, by first stooping to lift with the legs straight and secondly, by bending the knees and keeping the trunk upright. It was found that lumbar movements usually consisted initially of slight flexion, followed by continuous lumbar extension. The range of lumbar movement was approximately 50 degrees. It was also noted that when lifting in the deep squat position, the delay in onset of continuous lumbar extension was proportional to the weight of the load. Typically, lumbar extension began when the weight had reached between 25 and 50% of it's final height.

Angular Acceleration

Angular acceleration, or the rate at which the angular velocity of a body changes with respect to time, can affect the amount of stress placed on the low back during lifting tasks. As acceleration increases, there is a greater demand on the involved muscles and increased stress in the lumbar area (Andersson et al., 1976; Hay et al., 1983; Jager & Luttmann, 1989). Angular acceleration tended to vary among skilled and unskilled lifters. Unskilled lifters tended to be inconsistent in acceleration patterns, whereas skilled lifters demonstrated a positive angular acceleration for the trunk prior to lifting the weight (Brown & Abani, 1985).

Center of Gravity

Center of gravity (COG) is a theoretical point about which the sum of the segmental masses are balanced. It is the point where the sagittal, transverse, and frontal planes intersect. Shepard (1974) reported that the COG can also be outside the body. Scheuchenzaber (1983) reported that the COG for the average person is 55 - 57% of standing height in the anatomical position. The COG displacement can provide insight into the actual movement of the body.

Hay (1985) and Shepard (1974) reported that the COG changes depending upon the position of the body parts. Scheuchenzaber (1983) and Cooper and Glasgow (1976) also reported that the position of COG will change depending upon how the limbs are distributed around the body and on the specific location of these limbs. Ekholm et al. (1982) stated that during the first third of the lifting cycle, the COG of the body segments have long horizontal distances to the L5-S1 joint due to the flexing of the trunk. Chaffin et al. (1977) also reported that if the weight is held away from the body (i.e., horizontal at arm's length), the COG is displaced further away from the body. This places more stress on the back and shoulders.

Williams (1937) discussed COG in relationship to weak muscles. This author reported that weakened abdominal muscles will allow a protrusion of the abdomen. This will shift the body weight forward, thus changing the COG. The body will tend to compensate for this by increasing the extension of the lumbosacral spine. This causes increased force on the spinal discs.

Skilled Versus Unskilled Lifters

Troup (1984) stated that the greatest risk of back injuries occur in the younger, unskilled, and inexperienced worker. Raistrick (1981) reported that nurses frequently lift heavy weight throughout their workday, often with minimal training and practice in lifting/handling skills. Brown and Abani (1985) completed a study to determine differences among skilled and unskilled adolescents completing the dead lift. These authors found several differences between the skilled and unskilled lifters. The skilled lifters had a more upright posture and were less variable and more predictable in their lifting styles.

McLaughlin, Lardner, and Dillman (1974) also found several differences among skilled and unskilled lifters completing a parallel squat. They found that the descent portion of the parallel squat was completed differently by the less skilled lifters. The unskilled lifters allowed the bar's velocity to increase downward more than the higher skilled subjects. The less skilled subjects also maintained greater trunk lean and moved the hips and bar horizontally backward more than the high skilled group.

Grabe and Widule (1988) also analyzed weightlifters of different performance classification levels completing the clean and jerk lifts. It was found that kinematic characteristics of the jerk lift varied with the lifter's classification level. Skilled weight lifters demonstrated less horizontal displacement of the barbell during the squat than the unskilled lifters. Unskilled lifters had less horizontal velocity during the squat and the thrust phases and less trunk movement than the skilled lifters. McLaughlin, Dillman, and Lardner (1977) found that less skilled subjects demonstrated a larger increase in downward load velocity and maintained this greater velocity throughout the descent.

Kinetic Studies

Loading Moment

Ekholm et al. (1982) analyzed the loading moment for the L5-S1 area in various styles of lifts. These authors found that the loading moment at the L5-S1 region was very similar during lifting with the lumbar spine in a kyphotic position and lifting in a stooped position with the back muscles. They also found that if the weight was kept close to the body during the entire lift, the loading moment was reduced. Ekholm et al. (1982) also reported:

> During the initial phase of lifting a 12.8 kg burden, the loading moment caused by the body segments alone accounted for approximately two-thirds of the total loading moment... This showed that the proportion of the loading moment of force caused by the body segments themselves is considerable when light to moderate weights are lifted. Consequently, it is important when handling light to moderate weights in daily life, to be careful with the working posture. (p. 157)

The study completed by Ekholm et al. (1982) indicated that the lifting posture was very critical in determining the loading moment on the lumbar spine. Gracovetsky, Farfan, and Lamy (1977) reported that when lifting weight, the ligaments are the most effective elements that are used to balance the external loading moment at the intervertebral joints.

Force

Delitto et al, (1987) and Grieve (1974) reported the greatest loading moment of force at the lumbar intervertebral joints occurred in the central position of the lift (first four seconds). This is when the body must overcome the inertial forces necessary to complete the lift successfully. Brown and Abani (1985) also reported that the maximum vertical force at the ankle, knee, and hip were generally parallel with each other. The largest vertical force was in the middle or central portion of the lift.

Torque

Lifting with a relatively straight and upright spine by extension of the hips and knees creates smaller net torques than does lifting from a stooped posture (Grieve, 1977). McLaughlin et al. (1974) stated "trunk torques were consistently found to be considerably larger in magnitude than the thigh and shank torques during the lift. Trunk torque increased linearly the more a subjects's trunk angle decreased" (p. 186). It was also found that highly skilled subjects attempted to minimize trunk torque by reducing forward trunk lean.

Hay et al. (1983) found that the torque at the hips was effectively determined by the inclination of the trunk. If the trunk was near vertical, the torque at the hips was small, and if the trunk was inclined forward of the vertical, the torque at the hips was large. The torque at the knees was primarily a function of the torque at the hips and the angle of inclination of the thigh. The ankle torque was also influenced by the torque at the knees. It was also noted that increased external load caused increased hip, knee, and ankle torques.

Holmes et al. (1992) compared differences between spinal torque of the same subjects lifting an empty box and 30 pounds. They found that the L3 angle and torque was the same, although subjects took longer to lift the 30 pounds.

Muscle Activity

There was a general agreement among researchers that higher values of myoelectric signals are recorded when lifting in the stooped position versus lifting in a deep squat position (Andersson et al., 1983; Andersson et al., 1976; Carlsoo, 1961). The angle of the trunk had a significant impact on the amount of muscle activity. Carlsoo (1961) stated "the sacra-spinalis appears to be particularly susceptible to changes in the load distribution with very small changes in the position of the trunk, sufficing to produce appreciable variations in the electrical activity recorded from this muscle" (p. 208).

Andersson et al. (1976) reported when slow flexion of the trunk was performed to 45 degrees, there was a gradual increase in the myoelectric activity at all levels of the back, and an increase in intraabdominal pressure and disc pressure. The values decreased when the back was extended to the upright position. McLaughlin et al. (1974) also reported on the trunk position during the squat lift, by stating that although most sources indicate the squat to be primarily a leg extensor activity, the results of their study indicated that trunk extensors played a significant role during the squat lift. McLaughlin et al. (1974) also stated that because of the significant involvement noted in the trunk extensors, individuals weak in this area should be cautioned before using the deep squat for quadriceps development. Carlsoo (1961) found that during the deep squat lift, marked activity was recorded for the quadriceps and soleus.

Ekholm et al. (1982) reported that the erector spinae muscle was initially activated to a higher degree when lifting with flexed knees and the weight far from the spine, than when lifting with the knees flexed with the weight close to the spine. These authors also found that the rectus abdominis muscle showed no activity during lifting with flexed knees with the weight close or far from the spine. The oblique abdominal muscles also showed low activity during the lifts.

The findings reported by Ekholm et al. (1982) regarding no rectus abdominis muscle activity would appear to conflict with statements made by Gracovetsky et al. (1977) and Williams (1937). These authors reported that subjects with weak abdominal musculature would be unable to properly control their back ligament musculature. This would result in higher compression and shear values at the intervertebral joints and may lead to low back injuries. Results reported by Ekholm et al. (1982) indicated the abdominal muscles do not play a role during lifting.

Summary

A high prevalence of back injuries has been identified within the nursing profession. The cause of these injuries has been patient handling. There has been increased emphasis on educational injury prevention programs, with occupational therapy identified as the provider of these services. Due to the high prevalence of injuries within nursing, an educational injury prevention program may be indicated.

The recommended content of these educational programs is varied. Some health care professionals recommended general body mechanic instruction while others stated the importance of training specific to job tasks. From reviewing the literature, it appears programs using JST may obtain better results than those programs that were not job specific, however, there has been little research completed in this area. The use of a lordotic curve in the lumbar spine when lifting was also supported, as the spinal torque was reduced and muscle recruitment patterns better supported the lumbar spine.

With the major cause of back injuries in nursing being patient handling, a program focusing on these areas appeared to be appropriate. This study focused on job specific body mechanic training as recommended by Carlton (1987). The target population was nursing as this occupation was identified by researchers as a high risk occupation.

CHAPTER III

METHODS AND PROCEDURES

The methods section discusses the subject selection, the experimental treatment, and the development of instrumentation. It also includes methods of data collection, data reduction, and analysis.

Subject Selection

Permission was obtained from the chairperson of the nursing department at Viterbo College to ask second year nursing students to participate in this study. Twenty four nursing students volunteered to participate in the study. In addition, six prephysical therapy students also volunteered to participate in the study. The subjects were randomly assigned into one of three groups: an experimental group which received basic body mechanic training (BBMT); an experimental group which received BBMT and job specific training (JST) focusing on nursing tasks; and a control group (C) which received no training. There was a total of 10 subjects in each group. Subject characteristics are identified in Table 1.

Table 1. Subject characteristics

Group	Age	Height (inches)	Weight (pounds)
C	20.4	66.45	132.8
BBMT	26.8	64.00	145.2
JST	19.1	66.20	133.5

Student nurses and prephysical therapy students were chosen for this study as they had some knowledge of patient handling tasks, but limited knowledge of body mechanic techniques for these tasks. Student nurses and prephysical therapy students were also chosen as it was assumed that most of the students did not have a previous work history in the health care profession. It was therefore assumed that this population had not yet developed poor body mechanic techniques for patient handling tasks. Any prior exposure to body mechanic training and previous work history in a health care setting was assumed to be equally distributed among the groups, as subjects were randomly assigned to the three groups.

This study was limited to healthy female students to control extraneous variables. Differences in the subjects' age, height, and weight were assumed to be equally distributed among the control and experimental groups.

Subjects with a prior history of back problems were excluded from the study. Prior history was defined as back pain in the last year, significant enough that the subject needed to seek medical attention. These subjects were excluded to eliminate the risk of aggravating a previous condition.

Prior to participating in the study, a flexibility test of the lower back and hamstrings as described by Corbin and Lindsey (1991) was administered to the subjects. This was completed to identify those subjects who may not have had sufficient flexibility to safely complete the study.
The flexibility test consisted of the subject sitting on the floor with the knees together and the feet placed against a flat surface. The subject then reached forward with the arms as far as possible and this distance was measured. Corbin and Lindsey (1991) identified a flexibility rating scale that placed subjects into four categories. The categories were: low, marginal, good fitness, and high performance zone. All subjects fell within the good fitness or high performance zones.

An informed consent form (Appendix A) was given to each subject prior to participating in the study. The primary investigator reviewed the contents of the form with the subjects and they were given the opportunity to ask questions about the study.

Development of Instrumentation

A body mechanic evaluation checklist (Appendix B) was designed to evaluate the body mechanic techniques of each subject during work tasks. The checklist used in this study was based on the body mechanic evaluation checklists used by Carlton (1987) and McCauley (1990). The checklist used in this study was adapted to assess work related nursing tasks. Proper body mechanic techniques as defined by Melton (1983), Nachemson (1975), and Troup (1984) were also included in the checklist. The checklist was used to evaluate a one person pivot transfer from an adjustable table to a chair, and boosting a patient up in bed. Eight criterion were used to evaluate the one person pivot transfer with a total of 16 points possible. Boosting a patient up in bed was evaluated on six criterion with a total of 12 points possible.

The body mechanic evaluations were completed by three occupational therapists (the primary investigator, and two additional occupational therapists who were thoroughly trained in the evaluation process). There was a maximum of 2 points possible for each criterion. Evaluators gave the subject a score of 0 if the subject demonstrated minimal aspects of the criterion, a score of 1 if the subject demonstrated some aspects of the criterion and a score of 2 if the subject demonstrated most or all aspects of the criterion.

To establish intertester reliability or the degree of objectivity in the checklist, three subjects not participating in the study were videotaped as they completed a one person pivot transfer and boosting a patient up in bed. The three occupational therapists used the checklist to evaluate the three subjects on each of the simulated work tasks. The evaluation scores were analyzed by determining overall agreement of the evaluators as outlined by Fleiss (1981). There were six criterion for boosting a patient up in bed with two possible matches or chances for agreement for each criterion. To determine the total possible matches for this section of the body mechanic checklist, the following formula was used:

6 criterion X 2 possible matches X 3 subjects = 36 possible matches.

There were 34 matches among the three raters for boosting a patient up in bed. The 34 matches were then divided by the 36 possible matches and a 94.4% overall agreement was obtained. This same process was used to determine overall agreement of the one person pivot transfer portion of the checklist. There were 45 matches out of 48 possible matches yielding a 93.8% overall agreement.

Following the pre- and posttreatment videotaping sessions, the body mechanic evaluation checklist was used to evaluate the subjects' body mechanic techniques during the simulated work tasks. The three evaluators viewed the videotapes together and independently scored each subject. Evaluators were blind to the subjects placement into the experimental or control groups.

Data Collection

Upon arrival at the videotaping session, each subject was assigned a subject number and the subject's height, weight, and age were recorded. The procedures section of the consent form was reviewed with the subject.

The following landmarks were then marked on each subject with reflective tape: right side of the body (1) shoulder (at the glenohumeral joint), (2) elbow joint, (3) wrist, (4) top of iliac crest, (5) hip joint, (6) knee joint, (7) ankle (marked at the lateral malleolus), and (8) toe. The posterior of each subject was marked at (9) both shoulders, (10) both iliac crests, (11) both knees, and (12) both heels. A total of 16 areas were marked.

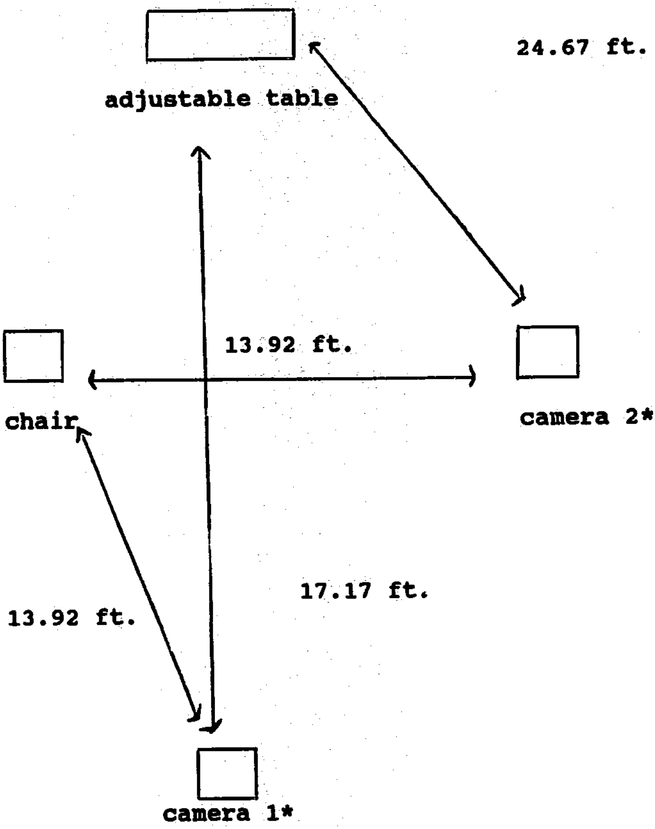
The subject was then videotaped completing the following simulated work tasks: one person pivot transfer and boosting a patient up in bed. Each subject randomly drew which task she was to complete first. The following standard instructions were provided to each subject:

Task one: (one person pivot transfer). Transfer the patient from a sitting position on the adjustable table to the chair. Adjust the height of the table and the position of the chair as indicated. There is a transfer belt available if you care to use it.

Task two: (boosting a patient up in bed). Boost the patient up on the table. Stand on the right side of the table. Adjust the height of the table if necessary.

The volunteer patient who participated in the simulated work tasks was a healthy male weighing 175 lbs and was 5.83 feet tall. He wore a full leg immobilizer on his right lower extremity and was not allowed to weight bear on this leg. He was instructed to require minimal assistance from the subject.

Subjects were videotaped with two videocameras operating at a nominal frame rate of 30 frames per second. Videotaping occurred in the Biomechanics Laboratory at the University of Wisconsin-LaCrosse. The subjects moved at right angles to the optical axis of one camera. The cameras were positioned as far away from the action as possible to minimize perspective error. The location of the cameras and equipment are depicted in Figure 1.



* Vertical height of camera 1 and 2 = 36 inches

Figure 1. Camera and equipment locations

A zoom lens was used to increase the size of the image. The cameras were secured to a stable tripod, sighted on the center of the action, and leveled. The background was plain, uncluttered, and provided a contrast to the subjects. Subjects were asked to wear light, solid colored tank tops and snug fitting shorts to the videotaping session. Sufficient light was used to expose the film and illuminate the subjects without distracting them. The cameras were started a few seconds before each trial to allow sufficient time for the cameras to reach the desired frame rate. The cameras were genlocked to insure that both cameras were synchronized. A time code generator was attached to provide an accurate measurement of time. A scale value was established to allow the conversion of film measurements to real distances. This was done by filming a meter stick in the plane of motion prior to filming the trials.

After the first videotaping session, the two experimental groups received the experimental treatment (BBMT or JST). Once the experimental treatments were completed, all subjects in the three groups were filmed again completing the same two simulated work tasks (one person pivot transfer and boosting a patient up in bed). The filming procedures were the same as previously outlined. After the second videotaping session, subjects were advised that the results of the study would be mailed to them. The subjects in the C and BBMT groups were also mailed the educational information on job specific body mechanic techniques for future reference.

Experimental Treatment or Procedures

The C group did not receive any training. Both experimental groups participated in a half hour lecture on basic body mechanic techniques. The session included a review of back anatomy, causes of back injuries, and body mechanic principles. The causes of back injuries were identified as poor posture, lifting weight in a stooped position (improper lifting technique), holding an object too far away from the body, not maintaining the natural curves of the back, and twisting. Body mechanic principles included lifting with leg muscles while keeping the back straight, maintaining back curves, maintaining a wide base of support, keeping the weight close to the body, and avoiding twisting. A muscle chart and a model of the spine were utilized in teaching back anatomy. Slides were used to show examples of proper body mechanic principles. There was no mention of specific work tasks during this instruction. Appendix C contains a copy of the handout given to the subjects during this training.

Following the completion of this session, the BBMT group was asked to leave and the JST group then received a half hour of job specific training as outlined below. This training took place in a classroom equipped with an adjustable table. The JST included basic transfer techniques, proper body mechanic techniques for the one person pivot transfer, and boosting a patient up in bed. Basic transfer techniques included reminders on safety during transfers such as standing as close to the patient as possible, using a transfer belt, and giving adequate instructions to the patient. Techniques taught for the one person pivot transfer included using a transfer belt, bending hips and knees simultaneously, maintaining spine alignment, proper foot and body placement, and avoiding twisting. Proper techniques for boosting a patient up in bed included proper foot and body placement, utilization of body momentum when moving a patient, avoiding twisting, maintaining spine alignment, and bending hips and knees when moving a patient. Appendix D contains a copy of the educational information given to the subjects during this training.

After the instructor demonstrated each of the job tasks, all subjects were given the opportunity to practice the tasks. During the practice time the instructor corrected any errors the subjects made. The occupational therapist providing the BBMT and JST was the primary investigator. This allowed for consistency during the training. All training took place at the University of Wisconsin-LaCrosse in the Biomechanics Laboratory.

Data Reduction

The Ariel Performance Analysis System (APAS) was utilized to evaluate videotaped data. Prior to completing the data reduction, the videotapes were viewed and the appropriate frames for each activity were selected. Several modules were used when evaluating and compiling the data. These are described in the APAS user's manual (1989) and are listed below:

The grabbing module: This module was used to capture the video sequences from the VCR and store them as computer files to be used for digitizing.

The digitizing module: This module was used after the grabbing module and allowed the body segments to be stored as Cartesian coordinates on the computer files. During the digitizing process, individual frames were viewed on the video monitor and the Cartesian coordinates of each joint were entered into the computer. The joint locations entered into the computer for the one person pivot transfer - up phase were as follows:

1. left toe	2. left heel
3. left ankle	4. left knee
5. left hip	6. left shoulder
7. left elbow	8. left wrist

9. top of head 10. tip of chin

For the one person pivot transfer - down phase and the side view of boosting a patient up in bed, the same joint locations were entered, however the right side of the body was used. For the rear view of boosting a patient up in bed, the following joint locations were entered into the computer:

1. left and right heel
2. left and right knee
3. left and right posterior iliac crest
4. left and right shoulder

For each activity a fixed point and two control points were also entered into the computer. These points allowed the image space to be calibrated for later conversion to true image space coordinates.

The transformation module: This module was used to convert the digitized video data into true two dimensional data. This module used a multiplier transformation method to complete the transformation.

The smoothing module: This module used a cubic spline function and was completed after the transformation module. This module allowed small random digitizing errors or noise to be removed from the transformed image sequence. Dainty and Norman (1987) stated that random errors may occur from misalignment or movement of the camera, perspective error, and stretching of the video. The smoothing process was able to remove these random errors from the body joint locations as it assumed that the movement patterns were smooth and continuous and could therefore be approximated by the cubic spline function.

The graphing module: This module was used after the digitizing, transformation and smoothing modules were completed. This module was used to obtain each subject's thigh and trunk displacement during the one person pivot transfer up and down phases and boosting a patient up in bed. This module was also used to obtain the center of gravity location of each subject for the boosting up in bed task.

Design and Analysis

The mean (group average) and standard deviation (SD) for the results of the body mechanic evaluation checklist and kinematic factors were obtained for the three groups. The Statistical Analysis System (SAS, 1979) data program was utilized to compute the analysis of variance (ANOVA) for the data. Witte (1989) stated that ANOVA is an overall test of the null hypothesis for more than two population means. The null hypothesis was tested with a F ratio. The F ratio is the variability between groups divided by the variability within groups. To make a decision regarding the null hypothesis, the observed F was compared with the critical F.

The degrees of freedom were 2 and 27. According to Witte (1989), for these degrees of freedom the critical F was 3.35 at the .05 level of significance.

After the null hypothesis was rejected, a post-hoc comparison was made with Tukey's studentized range test. The alpha was set at 0.05, the degrees of freedom were 27, and the critical value of studentized range was 3.506.

Separate ANOVA's were completed for the results of the body mechanic checklist for the one person pivot transfer and boosting a patient up in bed for the C, BBMT, and JST groups. ANOVAs were completed on the following:

1). Differences at pretest

2). Differences at posttest

3). Differences in pre- to posttest by group (this was calculated by subtracting the posttest mean score from the pretest mean score). This ANOVA indicated the amount of change that occurred in each group pre- to posttest.

Analysis of variance computed with the SAS program was also utilized to statistically analyze the kinematic data. The degrees of freedom, the critical F, and the post-hoc comparisons were the same as in the body mechanic checklist analysis. Differences at pretest, posttest, and differences in pre- to posttest by group were evaluated.

The following ANOVAs were completed for the kinematic data for the C, BBMT, and JST groups:

1. Segment angular displacement of the thigh and trunk during the up and down phases of the one person pivot transfer.
2. The COG displacement in the horizontal and vertical direction during boosting a patient up in bed.
3. Thigh and trunk angular displacement during boosting a patient up in bed.

Summary

The purpose of this study was to determine if the JST group used better body mechanics during simulated job tasks than the BBMT or C groups. Thirty subjects participated in the study. A body mechanic checklist was developed to evaluated the body mechanic techniques of each subject during the work tasks. Subjects were videotaped completing the simulated work tasks before and after the experimental treatment. The APAS was utilized to evaluate the videotaped data. The SAS data program was utilized to compute ANOVA's for the data.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

The purpose of this study was to determine if the JST group used better body mechanics during simulated job tasks than the BBMT or C groups. The results of the body mechanic checklist for the one person pivot transfer will be presented first, followed by a discussion of the first research question: Is there a significant difference between the body mechanic scores for the one person pivot transfer among the three groups? The results of the body mechanic checklist for boosting up in bed will then be presented, followed by a discussion of the research question: Is there a significant difference between the body mechanic scores for boosting a patient up in bed? The results of the kinematic analysis will then be introduced followed by a discussion of the research question: Is there a significant difference in the angular kinematics among the three groups.

Results of the Body Mechanic Checklist

The three evaluators viewed the videotapes and rated each subject's pre- and posttreatment performance on the two simulated work tasks. The mean of each subject's score was calculated for each job task before and after the experimental treatment (Appendix E). Overall agreement of the three evaluators was determined by using the method described by Fleiss (1981), and outlined previously in Chapter III in the section on the development of instrumentation. There were 30 possible matches for each job task. Overall agreement on the body mechanic checklist are presented in Table 2.

Table 2. Overall agreement on the body mechanic checklist

Task	Matches	%
Pretest - one person pivot transfer	26/30	87%
Pretest - boosting a patient up in bed	25/30	83%
Posttest - one person pivot transfer	25/30	83%
Posttest - boosting a patient up in bed	26/30	87%

The overall agreement for the study ranged from 83-87% which was lower than the 94% overall agreement obtained during the pilot study. The pilot study consisted of 3 subjects, whereas the actual study contained 30 subjects.

Inconsistencies among raters may have been missed because of the small number of subjects in the pilot study. Evaluation of the inconsistency between subject's scores, indicated that for the one person pivot transfer, the evaluators tended to vary on hip and knee position during up and down phases of the transfer and spinal alignment during transfer. No specific variations were noted for boosting a patient up in bed. This indicated that there was no particular aspect of the job task that was more difficult for the raters to evaluate.

The SAS data program was utilized to compute the ANOVA for the data. To make a decision regarding the null hypothesis, the observed F was compared with the critical F. The degrees of freedom were 2 and 27. According to Witte (1989), the critical F was 3.35 at the .05 level of significance for these degrees of freedom.

After the null hypothesis was rejected, a post-hoc comparison was made with Tukey's studentized range test. The alpha was set at 0.05, the degrees of freedom were 27 and the critical value of studentized range was 3.506.

Analysis of variance was calculated for the one person pivot transfer and boosting a patient up in bed for the C, BBMT, and JST groups. The following were included in the analysis: 1) Differences in mean body mechanic scores at pretest, 2) Differences in mean scores at posttest, and 3)

Differences in pre- to posttest mean scores by group (this was calculated by subtracting the posttest mean score from the pretest mean score). This ANOVA indicated the amount of change that occurred in each group pre- to posttest.

The ANOVA results for the one person pivot transfer are presented in Table 3.

Table 3. Results of the body mechanic checklist scores for the one person pivot transfer

ANOVA	Group	Mean (points)	SD	F ratio	P value
Pretest	1	7.50	2.99		
	2	9.57	7.60	1.06	0.36
	3	7.60	4.53		
Posttest	1	7.13	2.97		
	2	10.33	2.77	6.56*	0.005
	3	11.33	2.34		
Pre- to posttest	1	-0.37	2.87		
	2	0.77	1.94	6.10*	0.007
	3	3.73	3.18		

* statistically significant difference. Critical F = 3.35

The ANOVA completed for the pretest scores of the one person pivot transfer established that there were no significant differences among the groups at pretest, thus the groups were statistically the same prior to completing the experimental treatment. The ANOVA for posttest mean score differences indicated that the three groups were statistically different. A post-hoc comparison was therefore completed which revealed that the C group was statistically different than the BBMT group and the JST group. The BBMT group and the JST group were not statistically different from each other. This means that both experimental groups had higher mean scores than the control group.

The ANOVA for pre- to posttest mean score differences also indicated that there was a significant difference among the three groups. A post-hoc comparison was completed and revealed that the JST group demonstrated a statistically significant improvement in their score, compared to the C group. There was no statistically significant differences between the C group and the BBMT group or between the BBMT group and the JST group. There was no significant improvement in body mechanic scores for the BBMT group when compared to the C group.

The ANOVA results for boosting a patient up in bed are presented in Table 4.

Table 4. Results of the body mechanic checklist scores for boosting a patient up in bed

ANOVA	Group	Mean (points)	SD	F ratio	p value
Pretest	1	4.90	2.84		
	2	5.87	2.58	0.34	0.71
	3	5.60	2.67		
Posttest	1	5.20	2.27		
	2	5.80	2.10	18.64*	0.0001
	3	10.20	1.55		
Pre- to posttest	1	0.30	1.49		
	2	-0.07	1.53	21.30*	0.0001
	3	4.60	2.22		

* statistically significant difference. Critical F = 3.35

The ANOVA completed for the pretest scores of boosting a patient up in bed revealed no significant differences among the groups at pretest. Therefore, the three groups were statistically the same prior to the experimental treatment.

The ANOVA completed for posttest mean score differences indicated that there was a statistically significant difference among the three groups. The post-hoc comparison established that the JST group was statistically different than the C and BBMT groups. The JST group had a higher mean score than the other two groups, which showed that the JST group performed the simulated job tasks better than the other two groups. There was no difference between the C group and the BBMT group.

The post-hoc comparison of the differences pre- to posttest indicated that the JST group demonstrated statistically significant improvement over the BBMT group and the C group. The BBMT group did not demonstrate any significant improvement in their body mechanic scores when compared to the control group. These results indicated that the JST group demonstrated statistically significant improvement in their body mechanic scores when compared to the BBMT and the C groups. These results strongly support that JST is more effective than BBMT and no training at all.

Discussion of the Body Mechanic Checklist

This discussion section will focus on the research question: Is there a significant difference between the body mechanic checklist scores for the one person pivot transfer and boosting a patient up in bed among the three groups? The results of the one person pivot transfer will be discussed first followed by a discussion of the results of boosting a patient up in bed.

One Person Pivot Transfer

The ANOVA completed for the pretest scores of the one person pivot transfer established that there were no significant differences among the groups at pretest, thus the groups were statistically the same prior to completing the experimental treatment. It was therefore assumed that any changes in the means of the experimental groups were a result of the experimental treatment.

The ANOVA for posttest results as presented in Table 3, revealed that there was a statistically significant difference among the three groups at posttest. The control group was different than the BBMT and JST groups. The BBMT and JST groups had higher mean scores than the control group. At first glance, it may appear that both experimental groups were demonstrating an improvement in body mechanic techniques compared to the C group, however results of the post-hoc comparison of the differences pre- to posttest indicated this was not so.

The post-hoc comparison of the differences from pre- to posttest showed that the JST group demonstrated a statistically significant improvement in their body mechanic scores when compared to the C group. The BBMT group, however, did not exhibit a statistically significant improvement in their scores when compared to the C group.

It would appear that JST was more effective than the BBMT in improving the body mechanic techniques of the student nurses. This assessment, however, needs to be made somewhat cautiously. The post-hoc comparisons pre- to posttest did not indicate that the JST group demonstrated a significant improvement when compared to the BBMT group, but that the JST group was the only group that made significant improvements when compared to the C group.

Boosting a Patient up in Bed

The ANOVA completed for the pretest scores of boosting a patient up in bed revealed no significant differences among the groups at pretest. The three groups were statistically the same prior to the experimental treatment.

The ANOVA for posttest results as illustrated in Table 4, indicated that there was a statistically significant difference among the three groups at posttest. The post-hoc comparison of the differences at posttest showed that the JST group was statistically different than the C and BBMT group, with the JST group having a higher mean score than the other two groups. The post-hoc comparison of the differences pre- to posttest established that the JST group demonstrated statistically significant improvement in their body mechanic scores compared to the BBMT and the C groups. These results strongly support that JST is more effective than BBMT and no training at all. It also reveals that the BBMT was not statistically different than no training.

Health care professionals need to closely evaluate the contents of the injury prevention programs they are providing to industry. The results of this study support the idea that body mechanic training should be specific to the worker's job tasks. From the results of this study, it appeared that subjects who received BBMT could not apply the general principles they learned to their work performance. Results of injury prevention programs that are not job specific may be similar to no training at all.

In conclusion, there was a difference in the body mechanic checklist scores among the three groups, with the JST group demonstrating the most improvement in their scores pre- to posttest.

These results are similar to the findings of McCauley (1990) who completed a study to evaluate the effectiveness of JST on the work performance of newly employed young workers. McCauley randomly assigned subjects into two groups. One group received JST and the other group received safety orientation education with no application to actual work tasks. Body mechanic techniques for job tasks were evaluated with a body mechanic checklist for all subjects following the training. According to McCauley, the subjects who received the JST performed work activities using proper body mechanics significantly better than the subjects who did not receive this instruction.

Dortch and Trombly (1990) also support the effectiveness of JST over no training at all. These occupational therapists evaluated the effectiveness of an educational injury prevention program on hand use patterns of industrial workers. Eighteen subjects were divided into three groups. One group received no educational training, whereas the two experimental groups received information on repetitive motion injuries, anatomy and physiology of the upper extremity, and causes of injuries. Each of the experimental groups received a pamphlet describing job specific body mechanic techniques for the upper extremity. In addition, the second experimental group was given the opportunity to practice body mechanic techniques in a simulated work environment.

All subjects were observed completing work activities before and after the educational program. Body mechanic techniques used during job tasks were evaluated using a checklist. Dortch and Trombly (1990) found that the groups that received job specific injury prevention education significantly decreased the number of traumatizing movements during work activities.

Carlton (1987) examined the effectiveness of body mechanics training on the work performance of 36 food service employees at a small liberal arts university. Carlton found that there was no significant difference in work performance during lifting tasks between the group that received body mechanic training and the group that did not. The body mechanic training received by the experimental group did not take place at the work site and was not job specific. The results of Carlton's study are in agreement with the findings of this study, as it was found that the JST group was the only group that significantly improved their body mechanic techniques. The group that received BBMT was not statistically different than the group that received no training at all.

Results of the Kinematic Analysis

The absolute segmental angular displacement of each subject's thigh and trunk at the beginning and end of the one person pivot transfer and boosting a patient up in bed were obtained from the APAS. The one person pivot transfer was divided into two separate phases: 1 up phase, in which the subject moved the simulated patient from a sitting to a standing position, and 2 a down phase in which the subject lowered the simulated patient from a standing position to a sitting position. To obtain the total angular displacement of the thigh and trunk for each subject during the one person pivot transfer and boosting a patient up in bed, the end segment position was subtracted from the beginning segment position.

The COG displacements in the horizontal and vertical planes for boosting a patient up in bed were also calculated. The COG displacement for boosting a patient up in bed was analyzed, as it best estimated the horizontal and vertical movement of each subject's body while completing this task. It was assumed that if the COG was displaced while the subject completed the boosting a patient up in bed task, then the subject's body was moving as well.

The SAS program was again utilized to obtain ANOVAs on the data. The degrees of freedom, the critical F, and *post-hoc comparisons* were the same as in the body mechanic checklist analysis. The following ANOVAs were completed for the kinematic data for the C, BBMT, and JST groups.

1. Segmental angular displacement of the thigh and trunk during the up and down phases of the one person pivot transfer.
2. The COG displacement in the horizontal (X) plane and the vertical (Y) plane during boosting a patient up in bed.
3. Thigh and trunk angular displacement during boosting a patient up in bed.

Differences at pretest, posttest, and differences in pre- to posttest by group were evaluated.

The ANOVA results for segmental angular displacement of the thigh and trunk during the one person pivot transfer will be presented first. The COG displacement in the horizontal and vertical directions during boosting a patient up in bed will then be presented, followed by the thigh and trunk displacement during boosting up in bed.

<u>Thigh and Trunk Displacement During the One Person Pivot Transfer</u>

The ANOVA results for thigh and trunk displacement during the one person pivot transfer up phase are presented in Tables 5 and 6.

There were no significant differences in the angular thigh displacement during the one person pivot transfer up phase. There were also no significant differences in the angular trunk displacement at pretest and posttest. The ANOVA for pre- to posttest differences for trunk displacement during the up phase did indicate a difference among the three groups. A post-hoc comparison was completed which showed that the JST group was significantly different than BBMT and C groups. The JST group decreased the amount of trunk flexion that occurred during the movement, which may indicate that they completed the up phase of the transfer with less trunk movement.

The ANOVA results for thigh and trunk displacement during the one person pivot transfer down phase are presented in Tables 7 and 8. ANOVAs for the thigh and trunk displacement during the one person pivot transfer down phase did not reveal any statistically significant differences. Post-hoc comparisons were therefore not completed.

Table 5. Thigh segmental angular displacement during the one person pivot transfer up phase

ANOVA	Group	Mean (degrees)	SD	F ratio	p value
Pretest	1	15.28	9.03		
	2	10.57	8.07	0.59	0.56
	3	13.97	12.29		
Posttest	1	10.96	6.98		
	2	7.84	8.64	0.66	0.53
	3	11.99	9.49		
Pre- to posttest	1	-4.31	8.87		
	2	-2.73	6.03	0.10	0.90
	3	-1.98	17.56		

* statistically significant difference. Critical F = 3.35

Table 6. Trunk segmental angular displacement during the one person pivot transfer up phase

ANOVA	Group	Mean (degrees)	SD	F ratio	p value
Pretest	1	28.72	9.41		
	2	32.15	7.60	1.17	0.37
	3	25.81	10.63		
Posttest	1	25.30	8.39		
	2	18.69	9.51	2.54	0.10
	3	27.67	9.76		
Pre- to posttest	1	-3.42	9.71		
	2	-13.46	9.47	5.52*	0.01
	3	1.86	12.06		

* statistically significant difference. Critical F = 3.35

Table 7. Thigh segmental angular displacement during the one person pivot transfer down phase

ANOVA	Group	Mean (degrees)	SD	F ratio	p value
Pretest	1	9.37	10.36		
	2	4.85	2.65	1.06	0.36
	3	6.54	5.78		
Posttest	1	4.72	4.63		
	2	6.89	5.27	0.50	0.61
	3	6.32	5.17		
Pre- to posttest	1	-4.65	7.62		
	2	2.04	5.70	2.81	0.08
	3	-0.22	5.73		

* statistically significant difference. Critical F = 3.35

Table 8. Trunk segmental angular displacement during the one person pivot transfer down phase

ANOVA	Group	Mean (degrees)	SD	F ratio	p value
Pretest	1	18.76	12.64		
	2	14.78	7.33	0.50	0.61
	3	15.66	7.04		
Posttest	1	19.17	8.99		
	2	13.18	6.14	1.68	0.21
	3	16.79	6.52		
Pre- to posttest	1	0.41	8.17		
	2	-1.60	5.99	0.38	0.69
	3	1.12	7.50		

* statistically significant difference. Critical F = 3.35

<u>Center of Gravity Displacement During Boosting up in Bed</u>

The ANOVA results for the COG displacement in the horizontal direction are presented in Table 9.

Table 9. Center of gravity horizontal displacement during boosting a patient up in bed

ANOVA	Group	Mean (inches)	SD	F ratio	p value
Pretest	1	-6.12	2.51		
	2	-7.24	2.48	3.06	0.06
	3	-4.54	2.35		
Posttest	1	-5.24	2.75		
	2	-6.22	3.11	5.07*	0.01
	3	-9.85	4.20		
Pre- to posttest	1	0.88	2.12		
	2	1.02	3.25	8.39*	.002
	3	-5.30	5.62		

* statistically significant difference. Critical F = 3.35

The ANOVA completed for pretest results indicated that there was no significant differences among the three groups. There was a significant difference among groups at posttest. A post-hoc comparison was therefore completed which revealed that the JST group was significantly different from the C group. There were no statistically significant differences between the C group and the BBMT group or between the BBMT group and the JST group.

The ANOVA for pre- to posttest differences illustrated a significant difference among the three groups. The post-hoc comparison indicated that the JST group demonstrated statistically significant improvement over the BBMT and the C groups. The JST group increased their amount of horizontal displacement, which means the subject was moving her body in the direction she was moving the patient. The C group and the BBMT group did not demonstrate any significant improvement in their amount of horizontal displacement. This may mean that these two groups were rotating their upper bodies to complete the job task.

The ANOVA results for the COG displacement in the vertical direction are presented in Table 10. There were no significant differences among the three groups at pretest and posttest. There were also no significant differences pre- to posttest. This was expected, as this job task did not require a vertical movement of the patient.

<u>Thigh and Trunk Displacement During Boosting up in Bed</u>

The ANOVA results for thigh displacement during boosting up in bed are presented in Table 11. The ANOVA results revealed no statistically significant differences in thigh displacement among the three groups. The JST session did not advise thigh displacement during the actual movement of the patient, therefore, it would be expected that the JST group would not differ from the other two groups.

Table 10. Center of gravity vertical displacement during boosting a patient up in bed

ANOVA	Group	Mean (inches)	SD	F ratio	p value
Pretest	1	1.84	0.75		
	2	2.28	1.04	0.52	0.60
	3	1.94	1.20		
Posttest	1	1.56	1.05		
	2	1.84	1.75	0.38	0.68
	3	2.08	0.98		
Pre- to posttest	1	-0.28	1.25		
	2	-0.44	2.03	0.35	0.71
	3	0.13	1.40		

* statistically significant difference. Critical F = 3.35

Table 11. Thigh segmental angular displacement during boosting a patient up in bed

ANOVA	Group	Mean (degrees)	SD	F ratio	p value
Pretest	1	-7.29	8.10		
	2	-12.39	5.30	1.24	0.31
	3	-10.10	8.03		
Posttest	1	-8.66	5.58		
	2	-13.06	7.11	1.71	0.20
	3	-8.13	6.84		
Pre- to posttest	1	-1.37	7.87		
	2	-0.67	8.10	0.50	0.61
	3	1.96	7.71		

* statistically significant difference. Critical F = 3.35

The ANOVA results for trunk displacement during boosting up in bed are presented in Table 12. The ANOVA completed for pretest differences demonstrated that there were no differences among the three groups prior to the experimental treatment. There was no statistically significant differences at posttest, but there was a significant difference between pre- to posttest scores. A post hoc comparison was completed which demonstrated that the JST group was statistically different than the C group. The JST group increased their amount of trunk flexion which means the subjects positioned themselves closer to the simulated patient. The BBMT group was not statistically different than the C group, which indicated that the BBMT group did not position themselves any closer to the simulated patient than the control group. The BBMT group was not statistically different than the JST group.

Discussion of The Kinematic Analysis

The discussion section will focus on the research question: Is there a significant difference in the angular kinematics among the three subject groups? The results of segmental angular displacement of the thigh and trunk during the one person pivot transfer will be discussed first, followed by a discussion of the COG, thigh, and trunk displacement during boosting a patient up in bed.

Table 12. Trunk segmental angular displacement during boosting a patient up in bed

ANOVA	Group	Mean (degrees)	SD	F ratio	p value
Pretest	1	-0.73	5.06		
	2	2.37	6.07	1.12	0.34
	3	4.86	12.16		
Posttest	1	6.08	11.81		
	2	0.79	5.71	2.95	0.07
	3	-2.29	3.19		
Pre- to posttest	1	6.81	11.42		
	2	-1.58	7.31	4.28*	0.02
	3	-7.15	12.76		

* statistically significant difference. Critical F = 3.35

Thigh and Trunk Displacement During the One Person Pivot Transfer

It is considered proper body mechanics during a one person pivot transfer, to bend the knees, lifting with the legs while maintaining the spinal curves. It would therefore be desirable to note an improvement in thigh displacement and a decrease in trunk displacement following the experimental treatments, however, this was not the case. Overall, the ANOVAs of thigh and trunk angular displacement did not reveal any significant differences among the three groups with the exception of trunk displacement during the up phase. The ANOVA for pre- to posttest differences for trunk displacement during the up phase did indicate a difference among the three groups. The post-hoc comparison showed that the JST group was significantly different than BBMT and C groups. A comparison of the means illustrated that the JST group decreased the amount of trunk flexion that occurred during the movement, which may mean that they completed the up phase of the transfer with less trunk movement, and more thigh movement. This was not supported with the ANOVA of thigh displacement during the up phase of the one person pivot transfer.

Based on the kinematic analysis of the thigh and trunk displacement that occurred during the one person pivot transfer, it would appear that the JST was not effective in changing the body mechanic techniques of the student nurses. In contrast, the results of the body mechanic checklist analysis indicated that the JST was effective in changing the body mechanic techniques of the student nurses during the one person pivot transfer. There may be several reasons for the results of the kinematic analysis of thigh and trunk displacement during the one person pivot transfer not coinciding with the results of the body mechanic checklist.

The thigh and trunk displacement analysis was an objective measurement that assessed only two components of the one person pivot transfer - thigh angular displacement and trunk position. The body mechanic checklist was a subjective measurement that assessed eight components of the task. It could be possible that the subjects in the experimental group did poorly on the thigh and trunk displacement components, but did well on the other six components, resulting in an overall high score. It is interesting to note that the three evaluators varied the most in rating the subjects on thigh displacement during the transfer and spinal alignment. There appears to be a discrepancy between the subjective and objective measurement of thigh and trunk displacement. The evaluators had difficulty agreeing on the thigh and trunk movement that occurred during the transfer. These components may be more difficult to observe than the other aspects on the one person pivot transfer. Also, the ideal amount of actual movement was not specified in the body mechanic checklist nor has it been identified in the literature.

The thigh and trunk angular displacement analysis was two dimensional and evaluated only one side of the body. The subjects could have had more thigh displacement on the side of the body that was not included in the kinematic analysis. Improvements in thigh displacement may have been missed because of this. On the other hand, during the body mechanic checklist evaluation, the raters may have focused on both lower extremities, and may have noted the thigh displacement that occurred in both lower extremities. This could have resulted in a high score on the body mechanic checklist.

During the BBMT session and the JST session, the importance of spinal alignment was emphasized. The importance of decreasing the amount of trunk movement by keeping the trunk stationary when lifting and moving patients was not specifically addressed in the BBMT and JST educational packets. Therefore, the JST group, may have had proper spinal alignment during the transfer (scoring well on the body mechanic checklist) but still completed the actual movement of the patient by moving their trunk versus lifting with their legs. This may explain the lack of change in trunk displacement between the JST and C groups.

Center of Gravity Displacement During Boosting up in Bed

Boosting a patient up in bed required the subject to horizontally move the simulated patient 12 inches in bed. It is considered proper body mechanics if the subject had a high horizontal displacement, as this would indicate that the subject was moving her body in the direction of the patient's movement. An increase in horizontal displacement would demonstrate an improvement in pre- to posttest scores.

The COG displacement in the vertical direction was also evaluated. As previously mentioned, the subjects were asked to complete a horizontal movement, not a vertical movement. No changes in vertical COG displacement would therefore be expected among the three groups. Also, because the movement was not in the vertical direction, it would be expected that all subjects would have a lower COG displacement in the vertical direction compared to the horizontal direction.

Center of gravity horizontal displacement. As expected, the ANOVA for posttest results revealed that there was a statistically significant difference among the three groups at posttest ($F = 5.07$). The post-hoc comparison showed the JST group was significantly different from the C group. There were no statistically significant differences between the C group and the BBMT group or between the BBMT group and the JST group.

There was also a significant difference in the pre- to posttest scores ($p = 0.002$). The post-hoc comparison established that the JST group demonstrated statistically significant improvement over the BBMT and the C groups. The JST group increased their amount of horizontal displacement, whereas, the C and BBMT groups were not significantly different in the improvement of their amount of horizontal displacement.

The posttest mean horizontal displacement of the JST group was 9.85 inches. This was very close to the 12 inches the subjects were asked to move the patient. The posttest horizontal mean for the C group was 5.24 inches and for the BBMT group was 6.22 inches which is only half of the required distance the patient was to be moved. It would therefore appear that the subjects in the C and BBMT groups kept their bodies relatively stationary and completed the movement by rotating their upper bodies. The JST group on the other hand appeared to have moved their entire body in the direction the patient was going, thus avoided twisting of the upper back by moving with the simulated patient. This was confirmed by the body mechanic checklist, as the JST group performed the job tasks significantly better than the BBMT and C groups. Improper body mechanic techniques, specifically twisting of the upper body, were identified by Bettencourt et al.(1986) as a major cause of back injuries. The C group and the BBMT group demonstrated a high risk technique during boosting a patient up in bed.

These results would indicate that JST was more effective in improving body mechanic techniques, specifically by increasing the amount of horizontal displacement of the student nurses than the BBMT and C groups.

Center of gravity vertical displacement. There were no significant differences in the amount of vertical displacement among the three groups for the pretest, posttest and pre- to posttest. This was expected as the movement of the patient was not in the vertical direction. The JST group received no instruction to incorporate a vertical movement into this task during the JST program. As expected, the amount of vertical displacement was less than the horizontal displacement. The mean vertical displacement for the three groups ranged from 1.56 to 2.28 inches, whereas the mean horizontal displacement ranged from 4.54 to 9.85 inches.

Thigh and Trunk Displacement During Boosting up in Bed

Trunk displacement. Prior to discussing the results of the ANOVA, the desired trunk displacement for boosting a patient up in bed will be discussed. As presented under the COG discussion, the subject was required to preform a horizontal movement of the simulated patient. In addition to a large horizontal displacement, it is considered good body mechanics to have the subjects position themselves as close to the patient as possible by placing one arm under the patient's shoulders and the other under the patient's hips. In order for the subject to position herself in this manner, she would need to increase the amount of flexion in her trunk segment.

The post-hoc comparison of the COG displacement in the horizontal direction revealed that the JST group increased their amount of horizontal displacement. In addition to this, if the JST was effective, this group would also increase the amount of trunk flexion during the boost, indicating that they were positioned closer to the subject.

A post-hoc comparison of pre- to posttest differences in trunk segmental angular displacement showed that the JST group was statistically different than the C group. When analyzing the means, it was noted that the JST group increased their trunk flexion by 7 degrees, compared to the C group that decreased their trunk flexion by 6 degrees. This indicated that the C group had a relatively straight trunk and were positioned further away from the subject. Lifting an object while holding it too far away from the body was identified as a potential cause of back injuries by Anderson (1980), Andersson (1981), Bergquist-Ullman and Larsson (1977), Biering-Sorensen (1983), and Chaffin and Park (1974).

The post-hoc comparison of differences in trunk segmental angular displacement at pre- to posttest did not demonstrate any statistically significant differences between the C group and the BBMT group. This indicated that the BBMT group did not improve their trunk position following the BBMT session.

It would appear that JST was more effective than BBMT in improving the body mechanic techniques of the student nurses during boosting a patient up in bed. This assessment needs to be made somewhat cautiously, as the post-hoc comparisons pre- to posttest, did not establish that the JST group demonstrated a significant improvement when compared to the BBMT group. It did however show that the JST group was the only group that made significant improvements when compared to the C group.

Thigh displacement. The boosting up in bed task was analyzed from the start of the actual movement of the simulated patient to the point when the simulated patient stopped moving. Any thigh displacement should have occurred prior to the actual movement of the patient, and would not have been part of the kinematic analysis. As stated previously, the movement of the patient was in the horizontal direction and the proper body mechanic technique was a total body shift in the direction of the patient's movement. Minimal thigh displacement should occur during this task. If there was a large change in thigh displacement during the task, this would indicate a vertical movement of the subject's body. As noted previously in the discussion of vertical displacement of the COG, there was minimal vertical displacement noted in all three groups. It was expected that minimal changes in thigh angular displacement would be found in the three groups. The ANOVA supported this expectation, as no statistically significant differences in thigh angular displacement were noted among the three groups. In addition the JST session did not advise thigh displacement during the actual movement of the patient, therefore, it was expected that the JST group would not differ from the other two groups.

The results of the kinematic analysis are inconclusive in finding a significant difference in the angular kinematics among the three subject groups. The thigh and trunk displacement during the one person pivot transfer demonstrated no significant difference among the three groups. However, the results of the trunk and horizontal COG displacement during boosting a patient up in bed, indicated that JST group improved their body mechanic techniques, compared to the BBMT group and the C group.

Summary

Results of the body mechanic checklist indicated that the JST group demonstrated a statistically significant improvement in their body mechanic techniques compared to the BBMT and C groups. The results of the kinematic analysis varied. There were no significant differences in thigh and trunk displacement during the one person pivot transfer among the three groups. However, the results of the trunk segmental angular displacement and horizontal COG displacement during boosting a patient up in bed indicated that the JST group improved their body mechanic techniques, compared to the BBMT and C groups.

It appears that JST was the most effective in improving body mechanic techniques for boosting a patient up in bed, as there was statistically significant improvement in the body mechanic checklist scores and in the kinematic factors. Evidence supporting the effectiveness of JST for the one person pivot transfer was not as strong. Results of the body mechanic checklist scores indicated subjects improved their body mechanic scores following the JST. However, this was not supported in the findings of the kinematic analysis.

These inconsistences may have been a result of the narrower focus of the kinematic analysis, the fact that one side of the body was not included in the analysis or may demonstrate a weakness in the actual content of the training session itself. There also appears to be a discrepancy between objective and subjective measurements of thigh and trunk movement during the one person pivot transfer. These aspects of the task may be more difficult for evaluators to observe. Further research regarding subjective versus objective rating of body mechanic techniques may be warranted.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Cust, Pearson, and Mair (1972), Magora (1970), and Videman et al. (1984) reported a high prevalence of low back pain in nursing personnel. Injury prevention programs have been recommended as an effective method to decrease injuries. The most effective contents of these injury prevention programs needs to be identified in order to provide cost effective prevention programs for nursing personnel. Job specific training requires more time to complete than BBMT, however, if it is more effective, the extra time and cost would be justified.

The purpose of this study was to determine which type of training was most effective in improving the body mechanic techniques of student nurses during job tasks. The following research questions were evaluated: (1) Was there a significant difference between the body mechanics scores for the one person pivot transfer among the three groups? (2) Was there a significant difference between the body mechanics scores during boosting a patient up in bed among the three groups? and (3) Was there a significant difference in the angular kinematics among the three subject groups?

Twenty four volunteer student nurses and six prephysical therapy students participated in the study. Subjects were randomly placed into three groups, a control group that received no treatment, an experimental group that received BBMT, and an experimental group that received JST. Subjects were videotaped completing a one person pivot transfer and boosting a patient up in bed before and after the experimental treatments.

A body mechanic checklist was designed to evaluate the body mechanic techniques of each subject while completing the simulated job tasks, both before and after the experimental treatment. Segmental displacement of each subject's thigh and trunk and COG displacement was measured and analyzed using the Ariel Performance Analysis System.

The Statistical Analysis System program was used to analyze the results of the study. The following decisions were reached:

1. Results of the body mechanic checklist revealed that the JST group demonstrated a statistically significant improvement in their body mechanic techniques compared to the BBMT group and the C group.
2. The results of the kinematic analysis showed that there were no significant differences in thigh and trunk displacement during the one person pivot transfer among the three groups.

trunk displacement during the one person pivot transfer among the three groups.

3. The results of the trunk and horizontal COG displacement during boosting a patient up in bed demonstrated that the JST group improved their body mechanic techniques, compared to the BBMT group and the C group.

Conclusion

Student nurses who participated in the JST demonstrated an improvement in their body mechanic techniques during simulated work tasks, compared to the BBMT group and the C group. It appeared that the JST was the most effective in improving body mechanic techniques for boosting a patient up in bed, as there was statistically significant improvement in the body mechanic checklist scores and in the kinematic factors. Evidence supporting the effectiveness of JST for the one person pivot transfer varied. Results of the body mechanic checklist scores indicated subjects improved their body mechanic scores following the JST, however, this was not supported in the findings of the kinematic analysis. These inconsistences may have been a result of the narrower focus of the kinematic analysis, the fact that only one side of the body was investigated in the analysis or may demonstrate a weakness in the actual content of the training session itself.

Clinical Implications

Improper patient handling has been identified as a major cause of back injuries within the nursing profession. Injury prevention programs for nursing personnel may aide in reducing the number of back injuries within this occupation. The recommended content of injury prevention programs varied in the literature. Some health care professionals such as Carlton (1987) and Dembert (1990) recommended general body mechanic instruction while McCauley (1990) and Dortch and Trombly (1990) indicated the importance of JST.

Results of this study revealed that JST was more effective in improving body mechanic techniques of the student nurses than the BBMT. In this study, results indicated that there were no significant differences between the BBMT and C groups.

The cost of injury prevention programs is of concern to many companies. Although JST takes longer to complete and therefore would be more costly, it appears to be more effective in changing the work behaviors of the participants. Health care professionals and employers need to consider this when planning the content of their educational programs. It may be tempting to only provide a short, basic body mechanic training session that does not focus on specific job tasks, however, the findings of this study indicate that the results of this type of training would be similar to providing no training at all.

Suggestions for Further Research

Suggestions for further research include:

1. A three dimensional videotape analysis that allows the kinematic analysis of both sides of the body. This type of analysis may be more sensitive to changes in thigh and trunk displacement. It would also allow for an evaluation of rotation. This would provide insight into the amount of trunk rotation that occurred during the one person pivot transfer and boosting a patient up in bed.
2. Further research into the content of the JST session. It appears that more emphasis on trunk movement during job tasks may be necessary. It would also be interesting to further evaluate the most effective length of practice time that is incorporated into the training. The length of practice time may affect the amount of learning that takes place. Longer practice sessions may result in better work performance of the subjects.
3. A longitudinal study that monitors the incidence of back injuries in the JST group compared to the number of injuries that occur in the BBMT and C groups. This

would give insight into the long term effects on the JST program.

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APPENDIX A

INFORMED CONSENT FORM

APPENDIX A

Informed consent form

University of Wisconsin-La Crosse
La Crosse, Wisconsin 54601

Project title: The effectiveness of job specific training on the work performance of female student nurses.

Principal Investigator: Robin McCannon

(1) Procedures to be followed: Each subject will be videotaped completing two simulated nursing tasks. Tasks are: (1) one person pivot transfer, (2) boosting a patient up in bed. Subjects assigned to the experimental treatments will then participate in an injury prevention program. After completion of the program, each subject will be videotaped again completing the same tasks listed above.

(2) Potential discomforts or risks to be expected by the subject: The simulated patient will require minimal assistance from the subject to complete each task. This will reduce the amount of physical exertion required from the subject as much as possible. However the subject will still need to exert a physical effort when completing these tasks. There may be a small risk of injury to the muscles used during these tasks.

(3) Potential benefits to the subject and others: After completing this study, the subject will gain useful information regarding how to use her body effectively during lifting tasks. The subject will also be given feedback regarding her performance during simulated job tasks for future reference. The information gained will be helpful to the nursing profession in general, as insight will be gained in how injuries may occur. The effectiveness of injury prevention programs can also be determined.

(4) The study focuses on group data and for confidentiality purposes, each subject will be given an identification number to record data, rather than using the subject's name.

(5) The following people will have access to the original data of this study: the primary investigator, the thesis advisor, and two additional occupational therapists, who will be assisting in evaluating the data.

(6) The principal investigator will answer any and all inquiries concerning procedures, risks, or benefits.

I ___________________________, being of sound mind and ___ years of age do hereby consent to, authorize and request the person named above (and her co-workers) to undertake and perform on me the proposed procedures, treatment, research or investigation (herein called "Procedure").

I have read the above document, and I have been fully advised of the nature of the Procedure and the possible risks and complications involved in it, all of which risks and complications I hereby assume voluntarily. I do not hold the primary investigator, University of Wisconsin - LaCrosse or Viterbo College responsible for any injuries that I may develop as a result of participating in this study.

I hereby acknowledge no representations, warranties, guaranties or assurances of any kind pertaining to the Procedure have been made to me by the University of Wisconsin-LaCrosse; the officers, administration, employees, or by anyone acting on the behalf of any of them.

I understand that I may withdraw from the program at any time.

Signed at ____________________ this _____day ______, 19___, in the presence of the witnesses whose signatures appear below opposite my signature.

witnessed by:

____________________ ______________________

(subject)

____

APPENDIX B

BODY MECHANIC EVALUATION CHECKLIST

APPENDIX B

Body Mechanic Evaluation Checklist

INSTRUCTIONS FOR SCORING:
SCORE 0 IF SUBJECT DEMONSTRATED MINIMAL ASPECTS OF CRITERION
SCORE 1 IF SUBJECT DEMONSTRATED SOME ASPECTS OF CRITERION
SCORE 2 IF SUBJECT DEMONSTRATED MOST OR ALL ASPECTS OF CRITERION

ONE PERSON PIVOT TRANSFER

Criterion	Possible Score	Score
Utilized a transfer belt around patient's waist during transfer	0 - 2	____
Bent hips and knees during up phase of transfer	0 - 2	____
Bent hips and knees during down phase of transfer	0 - 2	____
Spine aligned during transfer (maintained natural back curves)	0 - 2	____
Subject's trunk in front of the patient	0 - 2	____
Feet shoulder width apart in a staggered stance	0 - 2	____
Patient was close to subject's body prior to standing up	0 - 2	____
Subject pivoted patient, keeping feet pointed in the direction she was going	0 - 2	____
Total	16	____

SCORING:
SCORE 0 IF SUBJECT DEMONSTRATED MINIMAL ASPECTS OF CRITERION
SCORE 1 IF SUBJECT DEMONSTRATED SOME ASPECTS OF CRITERION
SCORE 2 IF SUBJECT DEMONSTRATED MOST OR ALL ASPECTS OF CRITERION

BOOSTING A PATIENT UP IN BED

Criterion	Possible Score	Score
Placed hands under patient's hip and shoulder	0 - 2	____
Feet shoulder width apart in a staggered stance	0 - 2	____
Lead foot pointed in the direction the direction the patient was to be moved	0 - 2	____
Used body momentum when moving patient (Shifted weight side to side)	0 - 2	____
Spine aligned when moving patient	0 - 2	____
Bent hips and knees when moving patient	0 - 2	____
Total	12	____

Identification number: ______________________________

Date: ________________

Evaluator: ____

Comments: ____

APPENDIX C

BASIC BODY MECHANIC TRAINING

APPENDIX C

Basic Body Mechanic Training

I. Introduction

II. Anatomy of the healthy back

   A. Twenty four bony vertebrae make up the flexible portion of the spinal column.

   B. Separating the vertebrae are soft discs made of cartilage. They act as shock absorbers and allow the vertebrae to move.

   C. Muscles - support the back and maintain proper alignment.

   D. Chief functions of the healthy back:

      1. Support the upper body.

      2. Protects the spinal cord.

      3. Allows flexibility and provides a point of attachment for muscles and ligaments.

III. Potential Causes of Back Injuries

   A. <u>Poor posture</u> most back pain is a result of using the back improperly. Poor posture strains the back musculature and makes it more vulnerable to injury.

   B. <u>Improper lifting technique</u> increases strain to the muscles, discs, and vertebrae.

   C. <u>Holding an object too far away from the body</u> - holding two pounds close to the body puts two pounds of force on the lower back. As the weight is held further away form the body, the weight becomes heavier. Holding two pounds at arms length puts 200 pounds of pressure on the lower back.

D. Not maintaining the natural curves of the back - This places an unequal amount of pressure on the discs and may overstretch back muscles.

E. Twisting- Twisting places torque on the muscle tissue, thus making it vulnerable to injury.

IV. Prevention of Injuries Through Proper Body Mechanic Techniques

There are 5 basic body mechanic principles for back injury prevention:

A. Bend your knees- lift with leg muscles. These are the most powerful muscles.

B. Maintain a wide base of support- gives individual, better balance and control of weight.

C. Keep weight close to the body the further away you hold the weight from the body, the heavier the weight becomes.

D. Maintain the natural curves of the back maintaining the natural curves in the back keeps the muscles in proper alignment and an equal amount of pressure on the discs.

E. Keeping the body in balance to avoid twisting keep the weight in front of the body and between the feet, if possible. Avoid lifting weight that is off to the side of the body, point feet in the same direction you are going.

APPENDIX D

JOB SPECIFIC BODY MECHANIC TRAINING FOR STUDENT NURSES

APPENDIX D

Job Specific Body Mechanic Training for Student Nurses

Basic Transfer Techniques

1). Safety! Before you complete a transfer, ask yourself it the patient can be safely transferred by one person or do you need to get help.

2). Stand as close to the patient as possible. This is best done by asking the patient to slide to the edge of the bed before standing. This:

Gives the patient security.

Puts you in a good biomechanical position.

3). Use a transfer belt around the patient's waist for assistance.

4). Tell the patient what you will be doing and be sure he/she can see the surface he/she is transferring to. Ask the patient to help you as much as possible.

5). Stand with a wide base of support and bend your hips and knees, keeping your back straight as you assist the patient. Keep the following principles in mind when completing a one person pivot transfer and boosting a patient up in bed.

One Person Pivot Transfer

1). Patient should be able to assist with the transfer, if the transfer is being completed by only one nurse.

2). Place a transfer belt around patient's waist to assist with the transfer.

3). Have patient scoot to the edge of the bed. Make sure patient's feet are flat on the floor.

4). Position wheelchair at a 45 degree angle to bed and lock wheelchair.

5). Support involved leg with yours. Transfer patient in the direction of the non-involved side.

6). Firmly grasp the transfer belt.

7). Stand as close to the patient as possible.

8). As you bring the patient to a standing position, shift your weight from the front foot to the back foot and pull the patient up versus lifting him/her.

9). Pivot and lower the patient into the wheelchair by bending your knees.

<u>Boosting a Patient up in Bed</u>

1). Adjust bed to mid or upper thigh.

2). Cross patient's arms across his/her body. Bend patient's knees. If possible, have patient assist you by pushing with his/her feet and lifting head.

3). Work from the side of the bed, feet pointed in direction you will move patient.

4). Place one hand under patient's shoulder and the other under the patient's hips.

5). Count to three, so the patient knows when to help. While counting, shift your weight from the back leg to front leg to build body momentum.

6). This maneuver should be completed by shifting body weight using legs to complete task.

APPENDIX E

BODY MECHANIC CHECKLIST SCORES

APPENDIX E

Body Mechanic Checklist Scores

GROUP 1

	ONE PERSON PIVOT TRANSFER		BOOSTING A PATIENT UP IN BED	
S#	PRETEST	POST TEST	PRETEST	POST TEST
5	7	3	6	4.7
7	14	9	4	5
11	7	11	10	8
12	9	11	9.3	10
13	7	7	4	4
14	9	8.3	5	3.3
19	8	9	1	2
25	7	4	3.7	5
30	4	4	3	5
31	3	5	3	5

GROUP 2

1	13	13	10	10
2	10	11	3	6
3	11	11	6.3	6
6	12	13	5	4
8	12	10	5	4
16	7.3	8	3	4
17	8	8	6	4
18	9	8	7	6.3
21	10.7	15	10	8.7
22	2.7	6.3	3.3	5

GROUP 3

	ONE PERSON PIVOT TRANSFER		BOOSTING A PATIENT UP IN BED	
S#	PRETEST	POST TEST	PRETEST	POST TEST
4	6	11	2	10
9	14	14	9	10
10	11	13.7	8	12
15	10	10	5	12
20	4	9	9	11
23	15	15	8	11
26	3	12	5	11

27	3	10	4	9
28	5	11	3	7
29	5	7.7	3	9