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A Review of Sliding A Patient Up In Bed: Implications For Technique And Effects On The Low Back

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Review Article

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ABSTRACT

Healthcare workers are among the most injured workers in the United States, having injury rates similar to those in the construction industry. The most common body part injured in this population is the low back. There are many possible factors feeding into the injury of the low back including problems with anatomical structures, such as the intervertebral discs or multifidus muscles, biomechanics during patient transfers, and improper use of equipment. Some of these risk factors can be modified using friction-reducing transfer sheets or adjusting bed height, but as yet the risks remain high.

INTRODUCTION

Work-related musculoskeletal injuries are a common problem among healthcare workers [1]. These workers experience injury rates comparable to construction workers and others who have similar heavy lifting demands [2]. This is due to the frequent requirement of moving heavy patients. The recommended lifting limit for moving patients is 35 pounds utilizing an upright posture, the weight close to the body without trunk rotation [3]. The healthcare workers who have the greatest risk of contracting a musculoskeletal injury are nurses and nursing aids, but this category also includes occupational and physical therapists as they assist and train patients to learn useful transfer techniques [2,4,5]. Exacerbating the problem associated with manual patient handling is the regular use of inappropriate equipment and transfer techniques, including using unsuitable bed heights for the transfer process [3,6-8].

The most common injury site for healthcare workers is the low back [5,9]. As such, biomechanical and force investigations have focused on the low back, specifically the L4-L5 and L5-S1 vertebral levels [1,10]. These studies have highlighted the risk to healthcare workers and suggested limits to forces placed on the body along with methods for potentially reducing this forces. Even when incorporating current best practice methods for protecting healthcare workers, the forces are often over the limits and place employees in danger of musculoskeletal injury [10].

There are other factors that play into low back pain, including structural and functional degradation of the musculoskeletal system that can influence pain symptoms. Intervertebral disc degeneration has been implicated as a risk factor along with multifidus asymmetry or atrophy, but research has yielded conflicting results regarding the extent of the onus of low back pain due to these structures, but they are consistently implicated [11,12-21].

There are procedures, techniques, and certain methods that can be used to reduce the risk of musculoskeletal injury when performing patient handling tasks. Some of these are adjusting the bed to an appropriate height, using modern friction-reducing slide sheets, and choosing methods such as mechanical lifts when patients are too large or incapable and make the transfer task dangerous even with additional healthcare workers during patient mobility [22-24].

The purpose of this narrative review paper is to detail the following regarding patient handling in light of the current literature:

1. Injury prevalence and risks associated with patient handling tasks
2. Potential implications for the intervertebral discs
3. Biomechanics: forces and techniques

4. Potential implications for the multifidus
5. Potential interventions to reduce force
6. Future research
7. Conclusions

INJURY PREVALENCE AND RISKS ASSOCIATED WITH PATIENT HANDLING TASKS

Over the last several years there has been a great deal of research done to elucidate issues associated with low back pain. This research has ranged from attempting to discover the cause of the pain to how to ameliorate it both conservatively and invasively [25,26]. These projects have resulted in inconsistent evidence in both causes of low back pain and efficacy of interventions [11,27,28].

Employees of various physically demanding careers are placed at greater risk than others for contracting low back musculoskeletal injury [2]. Among these are healthcare workers; more specifically those who are required to perform manual patient handling tasks during every shift to assist with transfers or to administer effective therapy. Healthcare workers in hospital settings have been found to move up to 1.8 tons of weight throughout the workday [8]. It is therefore not surprising that musculoskeletal injuries are commonplace and pose a serious and far-reaching problem for these workers [29]. The possibility of getting injured has caused many healthcare workers to consider leaving their respective professions, especially if they have already experienced some type of musculoskeletal injury as there is a high likelihood of recurrence [4].

According to the Bureau of Labor Statistics for nurses and nursing aids, these professions cumulatively missed over 230,000 days of work in 2013 due to musculoskeletal injury, the majority of which come from patient handling incidents [2].

With obesity on the rise in the United States, patients are becoming larger and heavier [30]. With this increase in patient size, the load on healthcare workers' bodies also increases, which often leads to situations where the lifts that are being performed are no longer safe.

POTENTIAL IMPLICATIONS FOR THE INTERVERTEBRAL DISC

Damage to the intervertebral discs (IVD) is a risk factor for low back pain. The IVDs are important for transmitting forces through the vertebral column in a safe and effective manner [31]. They also allow for normal trunk kinematics including trunk flexion/ extension, lateral flexion, rotation, and combinations of these movements. Each IVD consists of three distinct parts, the vertebral endplates, the nucleus pulposus, and the annulus fibrosis [32].

The vertebral endplates are layers of hyaline cartilage that are typically less than 1 mm thick and tend to be thinner toward the center [33]. They are located along the lower and upper surfaces of the vertebral bodies immediately superior and inferior to the other parts of the IVD [33]. In order to provide required nutrients to the nucleus pulposus, the vertebral endplates allow for passive diffusion from the vertebral bodies to the center of the nucleus pulposus [33]. It also protects the vertebral bodies from penetration by the nucleus pulposus as well as helping to contain the nucleus pulposus in superior and inferior directions. If these fail the nutrition exchange of the entire disc is compromised which leads to accelerated degradation of the entire structure. Another potential implication is the extrusion of the nucleus pulposus in to the vertebral bodies which can alter force transmission and further complicate low back pain in healthcare workers.

The annulus fibrosus is composed of 15-25 concentric rings of collagen that run approximately 65 degrees from vertical in alternating directions [34,35]. These structures contain not only collagen, but also elastin which helps the IVDs to reform after movement or other stresses imposed on them. The organization of the annulus allows for stress to be applied in multiple directions while maintaining its integrity. It is particularly important for limiting the rotational movements of the trunk. Individuals who work in careers that require repetitive twisting motions such as healthcare workers as they repeatedly boost patients up in bed can experience a detrimental effect over time, leading to tears over time which eventually render it non-functional and lead to disc herniation.

The nucleus pulposus consists primarily of proteoglycans embedded in a matrix of type II collagen [36]. Proteoglycans are a group of molecules that are composed of sugars with at least one protein attached to them [37,38]. They consist of a core protein with one or more glycosaminoglycan (GAG) attached to them, which are smaller structures that also consist of sugar with a protein attached(39). The GAGs are negatively charged and thus strongly repel each other. The negative charge comes from acidic sugars and/or sulfate groups interspersed throughout the GAGs [40]. The negative charge is critical to imbibition, or uptake of water, during unloading, as it creates space between the small structures of the nucleus pulposus. This creates an appearance like a bottle brush in structure with the core protein being the center of the brush and the GAGs being the various bristles extending from the middle.

The unique composition of the nucleus allows it to deform when loaded between two adjacent vertebrae so it can receive force evenly from one direction and pass it on evenly in the other [35]. This can result in a decreased ability to imbibe water and thus impair proper force transmission, thus leading to further IVD degradation [41,42].

There has only been one imaging study completed that evaluates structural damage and change due to biomechanical loads placed on the body in healthcare workers [43]. This study used MRI to assess differences in four populations of workers, secretaries with low back pain, secretaries without low back pain, nurses with low back pain, and nurses without low back pain [43]. The results of the study showed Modic change differences at the L5/S1 level between secretaries and nurses, but no other substantial differences between those groups. There were correlates with the low back pain however, with an increased risk of back pain in those with nerve root compromise and endplate changes in the lower lumbar spine. This study did not use the type of MRI coil able to detect the early changes in disc structure though, and could be strengthened by using a sodium coil to observe early, small alterations in structure to obtain more precise results.

BIOMECHANICS: FORCES AND TECHNIQUES

When performing patient handling tasks several forces act on the low back. These are axial compression forces that affect most vertebrae and IVDs, and shear forces that act between the vertebrae in a lateral gliding motion, both anterior/posterior and laterally. These forces have been suggested to cause damage over time to low back structures [44].

The National Institute for Occupational Safety and Health (NIOSH) established upper limits for low back compressive and shear forces. Compression limits have been set at 6300 Newtons for a one-time event and 3400 Newtons for repetitive motions with shear limits of 1000 Newtons for a one time lift and 500 Newtons for repetitive tasks such as boosting a patient up in bed [3,6,45,46]. Further, a hand force limit has been set at 35 pounds in any one instance [47]. This is problematic, considering that the leg alone weighs more than 35 pounds in a typical 250 pound individual [48]. According to the NIOSH recommendations, the healthcare worker should use lifting equipment or assistance from another worker to lift even just a leg [48].

Many studies have assessed biomechanics and stresses acting onthe low back and possible technique modifications associated with lifting techniques to reduce potential sources of injury [1,3,7-9,11,21-24,45,49-58]. For instance, Marras, Davis, Kirking, and Bertsche discuss the spinal forces involved in various transfer tasks [45]. Those deemed "high risk" were forces that occurred when the participant was required to employ maximal sagittal flexion, a high lift rate, maximum external momentum, maximum lateral velocity, and high twisting velocity [45]. The high risk transfers involved forces that were 300 to 400 N greater for lateral shear force and 1300 to 1700 N greater for compression forces than lower risk transfer techniques [45]. The anterior-posterior shear force was relatively similar in most of the trials, whether high risk or not [45]. Even with two caregivers involved in the transfer task, none of them were considered safe for hospital personnel [45]. The shear forces involved also approached or exceeded the prescribed limits, thus showing that all of the transfer tasks performed in this study can be considered unsafe [45].

One quick and easy modification healthcare workers can make in hospitals and nursing homes to reduce the amount of stress and strain on the low back is adjusting the bed height prior to boosting a patient up in bed [7,57]. The generally approved guideline for an appropriate bed height for the task of boosting a patient up in bed is no more specific than raising the bed to the "waist or hip level of the shorter person" involved in the transfer [59,60]. This is a rather wide range. In addition, there is a concern that the taller healthcare worker in this scenario will still be at risk, so the best bed boost will occur with two healthcare workers that are the same height. The appropriate bed height has not been defined in reference to any specific bony landmark. However, the general guideline is to put the workers in a "better" position [21,57,61]. This is generally accepted to be a more upright, neutral posture in the trunk [21,57,61]. From a physics standpoint, this posture will decrease the lever arm for the trunk muscles, so less force will be required to perform the action of the transfer and therefore less force will be placed upon the structures of the low back.

Studies that focus on reducing low back force by way of adjusting positioning, specifically the bed height, have two major drawbacks. They either do not standardize the method of height adjustment or when standardized, the bed height is too low to make a substantial improvement on the overall force at the low back [1,7,10,51,53,55]. Studies that focus on friction-reducing transfer devices show that even with these devices the force limits and lifting limits are still being exceeded [1,10,22,58].

Bartnik and Rice and Larson, Murtagh, and Rice utilized similar methodologies to determine the low back force and hand force during a patient handling task using three different types of transfer devices [22,58]. The three different devices used were the disposable McAuley sheet, the reusable Arjo Maxi slide, and a standard cotton sheet. The outcome measures were the forces acting at the hand and low back. They found that even the more effective friction reducing materials resulted in hand forces that were well over the 35 pound recommended limit [22,58]. The results show that healthcare workers might still be at risk, even when using assistive devices that are available for patient handling tasks.

Recent technological advances to transfer devices have resulted in developing materials that are theoretically more effective at reducing load than the materials used in the Bartnik and Rice and the Larson, Murtagh, and Rice studies. One of these technologies is an air assisted device. It is being touted as having the ability to keep healthcare workers safe. However, they have limited utilization in real life circumstances as they are substantially more expensive than other available options and in some places are reserved only for bariatric patients.

Skotte and Fallentin showed an increased risk in repositioning tasks with patients who have some type of plegia [49]. This is due to a greater amount of force being put on the healthcare worker's body. Nine healthcare workers performed six different repositioning tasks with the patient in bed.

Another article observed the association between poor transfer technique and the subsequent increased risk for low back symptoms [55]. In this study 102 nurses were videotaped performing a boosting task and a transfer from a bed to a wheelchair. The techniques were then evaluated by physiotherapists [62]. The authors found that the nurses who were currently experiencing low back pain symptoms and those who have had symptoms within the last 30 days exhibited worse techniques (ie. more bending, twisting, etc.) than those without low back pain [55].

One difficulty healthcare settings face is that, even with the evidence promoting safe patient handling devices and techniques, workers often forego them, even when they are available. A study in 1992 found that transfer devices including hydraulic lift and gait belts were used less than 2% of the time [63]. Even among those healthcare professionals who have received extensive training with an emphasis on safe patient handling techniques, 78% are still using traditional methods as the standard of care due to time requirements of using friction reducing materials and costs associated with procuring appropriate materials [64].

POTENTIAL IMPLICATIONS FOR THE MULTIFIDUS

In addition to the intervertebral disc, other structures, such as muscles (eg: The multifidus) and the vertebrae themselves, including the facet joints,are potential sources of pain [11,27,28]. Structural deficits and degradation are not always associated with symptoms, but have been shown to increase the overall likelihood of having low back pain [11].

Multifidus are a set of small muscles of the back. They originate from the transverse processes of lower vertebrae, travel superiorly two to four vertebral levels, and then insert on the spinous process [65]. These muscles are involved in back extension when used bilaterally and trunk rotation and side bending when used unilaterally [65]. Several studies determined that an atrophic response or imbalance amongst these muscles can contribute to low back pain and that the amount of atrophy was more important in determining pain than the symmetry of the muscles [12,14,15,66]. Some vertebral levels are implicated more than others [12].

Beneck and Kulig showed that lumbar multifidus atrophy occurred in participants with low back pain only at the L5-S1 level [12]. The superior and inferior spinal levels, specifically L4-L5 and S2-S3, were both shown to statistically have the same volume between subjects with pain and pain free controls, as well as having no difference in any level of erector spinae. Similarly, Wall work and colleagues in 2009 showed that participants who experience chronic low back pain have significantly smaller multifidus in the low back at the level of pain compared to those without chronic low back pain [16].

Hides et al showed that asymmetry of the multifidus was associated with low back pain, and that the side with a smaller cross sectional area was the side that exhibited pain [15]. In contrast, the same researchers found in another study that the asymmetry in lumbar multifidus and other trunk muscles in elite cricket players did not have any bearing on pain [67]. These studies lend evidence to the complexity of low back pain and attempting to pinpoint the source.

Muscle activation is an important part of any physical task. Many times our muscles need to fire symmetrically, but in many other cases it is important that they fire asymmetrically. When completing a patient transfer, such as boosting a patient up in bed, it is expected that muscles on one side of the body will fire more than those on the other so that an asymmetrical motion can be completed.

One method for measuring muscle activation is surface electromyography (EMG) [68]. An EMG study from 2016 induced experimental low back pain in their subjects and observed a variety of outcomes related to pain, including muscle activation [18]. The authors found that when participants experienced back pain they had a higher rate of co-contraction than when they had no pain [18]. This could be due to the desire of the participants to stabilize their core more and minimize trunk movement. The movements in this study were different than those utilized by healthcare workers, but similar reactions can be inferred with naturally occurring acute pain.

An older study performed in the 1980's compared muscle activation in subjects with chronic pain subjects without pain. The authors found substantial differences when the participants were completing various low back motions [19]. The motions completed by the participants included trunk flexion and extension as well as trunk rotation, motions that are very typical for a healthcare worker [19]. The authors found that those with low back pain and controls had similar resting muscle activity, but that during dynamic activities those with low back pain showed much lower EMG levels in addition to restricted range of motion during the activities of the study [19]. Extrapolating these data to healthcare workers, those who have low back pain are likely limited in their ability to perform patient handling tasks both in muscle activation and range of motion. In turn, this can lead to further damage to the low back of the healthcare worker resulting in a downward spiral.

There are 2 studies regarding muscle activation that specifically target healthcare workers as subjects [69,70]. One of these involves training healthcare workers to have a better response to sudden loading of the back, which is drastically different than typical patient positioning tasks during a normal workday [69]. The other study assesses and compares erector spinae muscle activation before and after a typical shift [70]. They found that at the end of a shift each of the participants displayed reduced muscle activation with isometric back extension, suggesting muscle fatigue due to working with patients.

POTENTIAL INTERVENTIONS TO REDUCE FORCE

In order to reduce the amount of low back force during patient handling tasks, the healthcare worker needs to stay in an upright posture and minimize twisting during the transfer task. This will decrease the moment arm for the trunk which will reduce the overall compressive force when the hand forces remain unchanged. Remaining in a more neutral posture will also decrease the amount of shear force during transfer tasks as there will be less twisting occurring during patient handling. Overall, a more upright posture with less trunk flexion keeps low back forces closer to the recommended force limits rather that going way over those limits.

A zero lift policy in nursing homes has been linked to a decrease in injury rates of employees and a subsequent decrease in workman's compensation claims and payouts [24]. This is, however, not a commonly implemented practice for the reduction of musculoskeletal strain. This is in part due to the excessive cost associated with lifting equipment. The facilities in the paper spent $150,000 on equipment for every room in the facility. However, they were able to recoup the costs in 3 years due to the decrease of employee injuries and the reduction of workman's compensation.

As mentioned previously, changing bed height is an easy modification healthcare workers can make to decrease the load on the low back. This can be easily overlooked as it increases the amount of time a healthcare worker spends in the room for a simple task that takes seconds, but this simple action can reduce the strain on the low back when boosting a patient up in bed or performing a lateral bed to bed transfer [59]. Unfortunately, the recommendations are not very precise, but the healthcare worker should raise the bed high enough that he or she can remain in an upright posture when completing the patient positioning task, generally accepted as between the hip or waist height of the caregiver [59].

Another modification that could have far reaching effects on caregivers is changing the kind of transfer sheets. There are remarkable friction reducing devices available that can serve to reduce the amount of force required by up to 58% when performing certain patient handling tasks [71]. This reduces the amount of stress on the low back of healthcare workers as the hand force required is decreased even when the healthcare worker stays in the same posture. This can reduce fatigue and improve the work environment. There are some devices that perform better than others and some that must be doubled up to be effective, but when used as directed, these devices are effective at reducing low back force during patient handling tasks [22,58,71].

FUTURE RESEARCH

The optimal bed height for transfers is a key topic in this genre. A systematic technique to discover ideal bed height for the lowest low back force is still lacking in the current literature. Either a standard bed height is used with no respect to the height of the healthcare worker, or a self-chosen bed height is used in all recent studies. Further insight could be gained from looking at low back force at many different bed heights and determining if there is an ideal height that balances compressive force versus shear force.

Previous biomechanical studies have focused mostly on nursing professionals, but should also include occupational therapists, physical therapists, occupational therapy assistants, and physical therapy assistants. These populations also experience high rates of musculoskeletal injury and are known to have considered leaving their respective professions due to the high risk of such injuries [4,5].

Low back muscles in healthcare workers also have much to be discovered, particularly the multifidus. Symmetry, atrophy, and activation of the multifidus can be a factor in low back pain which can affect healthcare workers in a significant way. Imaging and EMG studies should be completed that focus on the multifidus in a population of healthcare workers to determine if these muscles are a factor in low back pain with this population in particular. If they are, follow up studies should be completed which look at rehabilitating these muscles in healthcare workers to observe what happens to them and to low back pain over time. If targeting the multifidus for rehab programs is successful at reducing the amount of low back pain in healthcare workers that could be a real breakthrough at reducing the amount of on the job injuries for this population.

Reducing the hand force is another intervention that needs to be improved. Friction reducing materials that are commonly used in healthcare settings do not consistently reduce the amount of hand force to below the recommended 35 pounds for lifting tasks. Other more effective friction-reducing materials should be studied in the laboratory and in hospital and skilled nursing settings in order to gauge the effectiveness of the materials and the utilization in real life settings.

CONCLUSIONS

With all the information available regarding patient handling it can be daunting to try to take in. This review summed much of the available literature for easy access to the savvy healthcare professional.

There is ample evidence to show the risk healthcare workers take on a daily basis when performing patient handling tasks. The risks include damage to the IVD, atrophic multifidus, improper activation of low back muscles, and poor biomechanics.

These risks can be reduced by global and individual modification of specific risk factors. It is important that healthcare workers utilize the materials available to them for patient handling tasks including using friction-reducing materials and appropriate bed heights. There are new materials and equipment coming out frequently that can further reduce the risk to healthcare workers if utilized correctly and consistently. However, even with these technologies healthcare workers are at risk.

Healthcare workers need to exercise caution when deciding when and how to manually handle patients and modify environmental risk factors as much as they can in order to prevent musculoskeletal injury.

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