

# **Analyzing Risk Factors Associated with Bariatric Patients Handling using JACK Software**

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## **Abstract**

This paper focuses on evaluating the safety and health hazards on patients handling nurses. Manual patients handling, especially for bariatric (overweight patients) can be very risky. An experiment was conducted using digital human modeling; JACK software to measure and analyze the effect of repositioning and lifting procedures of patient handling on the lower back. Patient handling procedures was improved by showing the proper number of nurses required and the ideal anthropometries for nurses that will ensure no risk for the nurses.

## **Keywords**

Bariatric Patient Handling, Digital Human Modelling, JACK software, Musculoskeletal Disorders (MSDs)

## **1. Introduction**

Musculoskeletal disorders (MSDs) are injuries or pain in the body's joints, nerves, tendons, ligaments, muscles, and structures that support the limbs, neck and back. Frequent causes of lower-back injuries involve the lifting of a heavy object, lifting while twisting, or sudden movement. Patient handling tasks are physically demanding, and usually performed under unfavorable conditions especially when dealing with bariatric patients. A single nurse in an 8-hour shift is required to lift a load equivalent to 1.2 tons (Ha, C. et al. 2014). Moreover, the load lifted by the nurse is often in an awkward position (Nelson and Baptiste, 2004). One of the earliest challenges that ergonomists faced was the measurement of work effort and fatigue in a workplace. However, now professionals measure the risk associated with the work procedures using ergonomic assessment tools such as Digital Human Modeling (DHM) in JACK software. The program facilitates the measurements of risk. DHM is particularly important in healthcare simulations and studies. As a matter of fact, the healthcare tasks include complex postures and activities that are difficult to simulate in real-life experiments (OSHA, 2014).

In a local hospital in Kuwait, some nurses who works in patents handling complained from lower back injuries. This was clear through excess absence days of the nurses. One of the useful approaches is using the mechanical patient handling equipment which reduce the load during patient handling to prevent the occurrence of lower-back injuries (Koppelaar et al, 2012). However, as patient handling equipment are not always available in all places, this paper will focus on the manual patient handling to determine the proper number of nurses needed to perform the task.

## **2. Literature Review**

In the lower-back, a strain or tear in the muscles and/or ligaments causes the area around the muscle to become inflamed which leads to back spasm. Back spasm leads to difficulty in moving and increases the lower-back pain. (Ullrich, 2007) Lower-back injuries are caused by any type of procedure that puts stress onto the lower-back. Patient handling requires the caretakers to push, pull, carry, lift or reposition a patient. Moreover, the tasks are physically demanding, and usually performed under unfavorable conditions. Nevertheless, the procedures required to be done by the nurse is often in an awkward position, such as bending or reaching under the bed or chair while the nurse's back is flexed (Nelson & Baptiste, 2004).

The most common patient handling approach is manual patient lifting. Manual patient lifting can cause micro-injuries to the spinal cord specifically in the L4, L5, and S1 (OSHA, 2014). Moreover, the negative impact of

manual patient lifting among the nurses are damage to the shoulders, bruising of arms, lower-back pain, and loss of dignity (Nelson & Baptiste, 2004).

On the other hand, transferring or reposition a patient identified as one of the most common causes of MSDs (Wilson et al, 2015). 90% of the lifting efforts made by nurses is for repositioning the patients in the bed they are already in (OSHA, 2013). Moreover, the high-risk tasks include patient transfer in and out of personal vehicles (particularly when the patient is ill), reposition a patient in bed, vertical transfers of patient from bed to stretcher or operating room table (Nelson & Baptiste, 2004). This tasks requires the body to bend and twist, that will harmfully affect the caregiver (OSHA, 2014).

Many ergonomic risk assessment tools, such as Rapid Upper Limb Assessment (RULA), Movement and Assistance of Hospital Patients (MAPO), National Institute of Occupational Safety and Health (NIOSH) lifting equation were used to measure the risk associated with the work procedures. They were also used to improve the protocol to avoid several injuries in the workplace. Digital human modeling, especially JACK software facilitate the measurements of risk. It provides the ability to do experiments and scenarios that cannot be done in real-life.

### 3. Methodology

The methodology used in this study is shown in Figure 1.

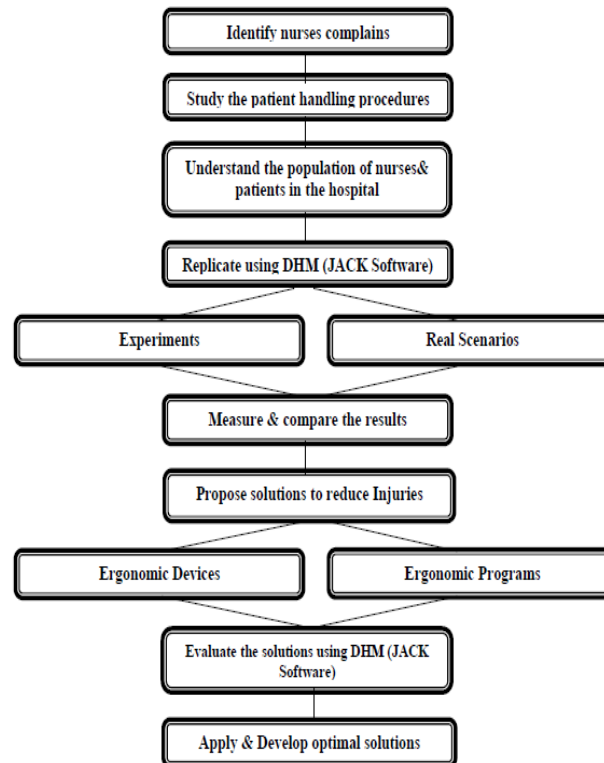


Figure 1. Methodology

A survey was conducting among 53 nurses in hospital who are involved in patient handling, several nurses complained from the injuries caused by the patient handling. 85% of nurses announced that they suffered from MSDs during patient handling. Lifting and reposition patients are the procedures that the nurses complained the most as shown in figure 2. Therefore, this study will focus on these two patients handling techniques.

To understand repositioning and lifting, two different digital human models were built using JACK software. The first focuses on the reposition process, while the second focuses on the lifting process. As most of nurses face difficulty dealing with Bariatric patients, an obese patient (120 kg) was modeled. The anthropometries of the nurses vary; therefore, the anthropometric data of nurses were measured. JACK software can classify the anthropometries into 3 levels: 95th, 50th, and 5th percentile for both height and weight.

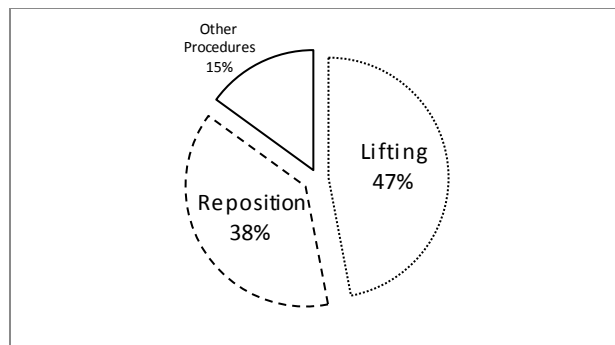


Figure 2. Nurse Survey Results

The current reposition procedure requires two nurses to participate in the procedure. One nurse pulls the patient from the hand and shoulder, and the other nurse pushes the patient from the back. While for the lifting procedure, two nurses pull the patient from the hand and shoulder. As most of nurses complains of the difficulty of handling overweight (bariatric) patient, the study focused on overweight patients i.e. the patient weight is 120 KG.

Figure 3 shows the main steps of patient repositioning: P1, P2, P3, and P4. These steps were studied to understand the effect of the procedure on the lower back through measuring the forces the (L4-L5).

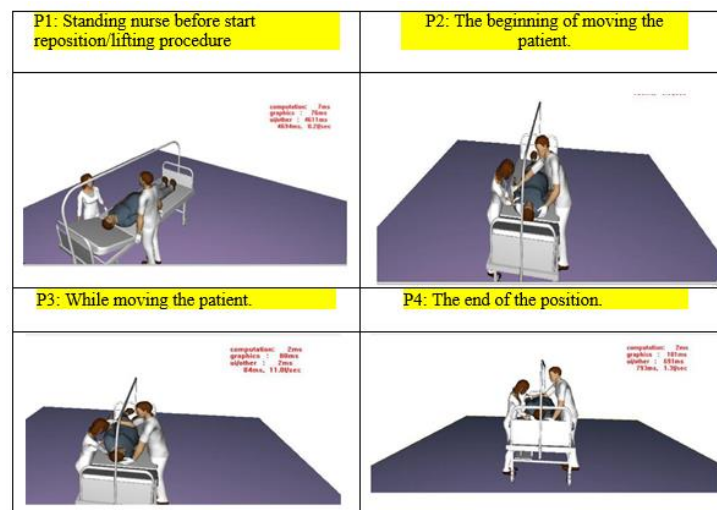


Figure 3. Main steps of patient repositioning using JACK software

Figure 4 shows the main steps of patient lifting: P1, P2, P3, and P4. These steps were studied to understand the effect of the procedure on the lower back through measuring the forces the (L4-L5).

An experiment was design to test the influence of the gender, height, and weight (independent factors) of the nurses on the compression forces induced on the lower back (dependent factor). The aim of this test is to identify positions that will result on a risk on the lower back of the nurse. The factors and their levels are listed in Table 1.

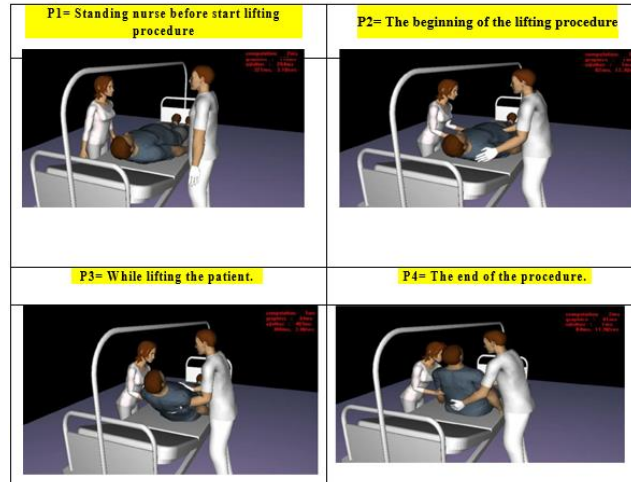


Figure 4. Main steps of patient lifting using JACK software

The optimal force per the National Institute of Occupational Safety and Health (NIOSH) is less than 3400 N, higher force up to 6300 N is considered risk, and if the force exceeded 6300 N there is a high risk. JACK has these limits built-in in LPA tool. The compression forces on L4/L5 were calculated using lower back analysis tool.

Table 1: Design Matrix for Reposition and Lifting

Factor	Level	Values
Nurse Gender	2	Male, Female
Nurse Height	3	5 <sup>th</sup> , 50 <sup>th</sup> 95 <sup>th</sup> Percentile
Nurse weight	3	5 <sup>th</sup> , 50 <sup>th</sup> 95 <sup>th</sup> Percentile

## 4. Results

For the positions P1, P2, and P4 in both models of reposition and lifting; all forces for weights, heights, and gender were under 3400 N. Therefore, these positions are considered safe. On other hand, P3 in reposition and P3 in lifting procedures show high values of forces induced on L4/L5 area i.e. greater than 3400N. Using Balanced ANOVA, the results of experiment showed that gender, height, and weight are significant factor for both repositioning and lifting with all p-values were <0.01. As only P3's in reposition and lifting are risky positions, the proposed improvements focused on them to reduce the risk of implementing these tasks.

### 4.1 Reposition

In the simulated reposition experiment, two human model nurses were involved in the procedure. The results in Figure 5 show a high risk for P3. The P3 for all the anthropometries (The height and weight for the nurses of 95<sup>th</sup>, 50<sup>th</sup>, and 5<sup>th</sup>) and genders exceeded the optimal force and reached to a High-Risk force on the lower back of the nurse. Therefore, all nurses in the local hospital are in high risk while participating in a reposition procedure of a bariatric patient (120 KG). The procedure is dangerous on the nurse's lower backs and should be changed or improved immediately. Furthermore, the results show that females suffer higher lower back forces than males. Therefore, the female nurses should be excluded from handling bariatric patients.

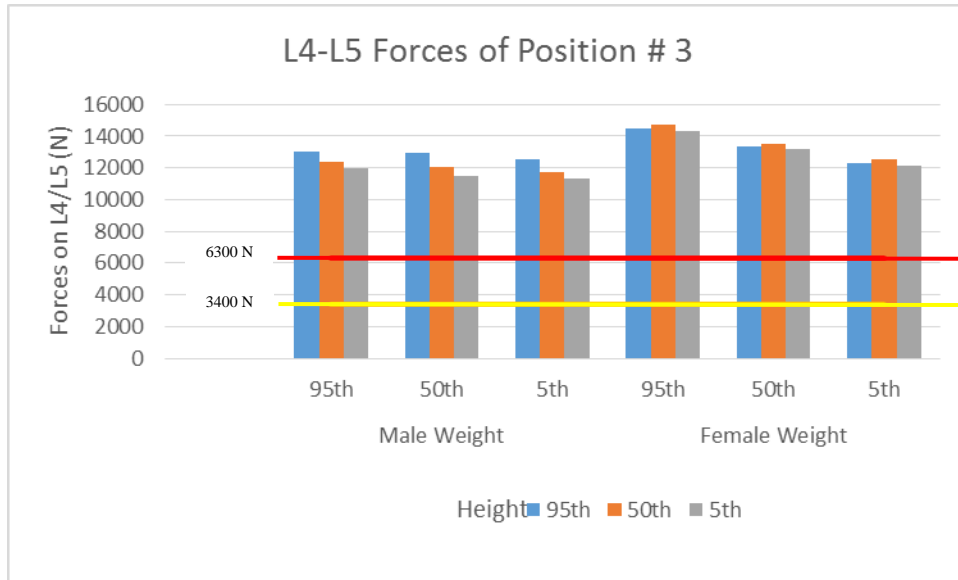


Figure 5. Lower back forces for P3 step in reposition procedure for male and female nurses

#### 4.2 Lifting

As handling bariatric patients is not suitable for female patients, the task was analyzed only for male nurses. Like the reposition experiment, the results of lifting experiment in figure 6 showed a variable risk ranged from little to high risk. The P3 for all the weight and height anthropometries exceeded the optimal force on the lower back of the nurse.

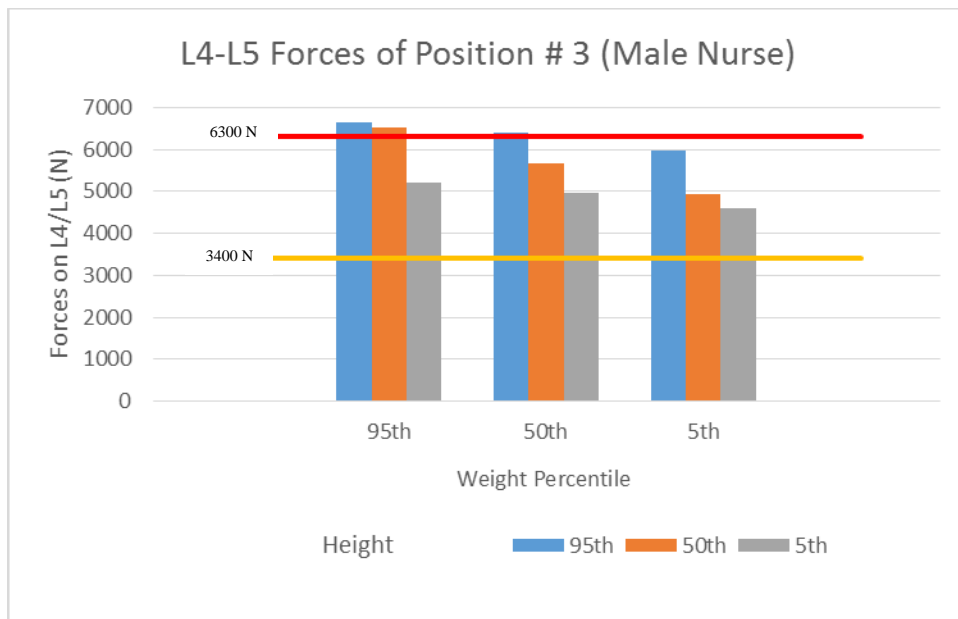


Figure 6. Lower back forces for P3 step in lifting procedure for only male nurses

The little risk level causes micro injuries on the nurse's lower back. The micro injuries cause pain and MSDs on the long term. On the other hand, the high Risk should be changed or improved immediately as it results in a serious injury.

## 5. Improvements

The current patient handling procedures of reposition and lifting showed that the procedures are not safe and with a risk on the health of the nurses. Therefore, improvements on both procedures were studied using JACK software; more nurses were added to assist in reposition or lifting patients. The aim of the improvements is to reach the optimal number of nurses that will cause no risk to the nurse's lower back.

### 5.1 Reposition

To reduce the force on the lower back, more nurses were added to assist in the procedure. when 1 nurse was added, the risk level, as well as the force compressed on the lower back is decreased. The decrease was clear, but still has a risk on the lower back of the nurses. After that, 2 extra nurses were added, the forces reduced to much closer values to the safe limit as shown in figure 7.

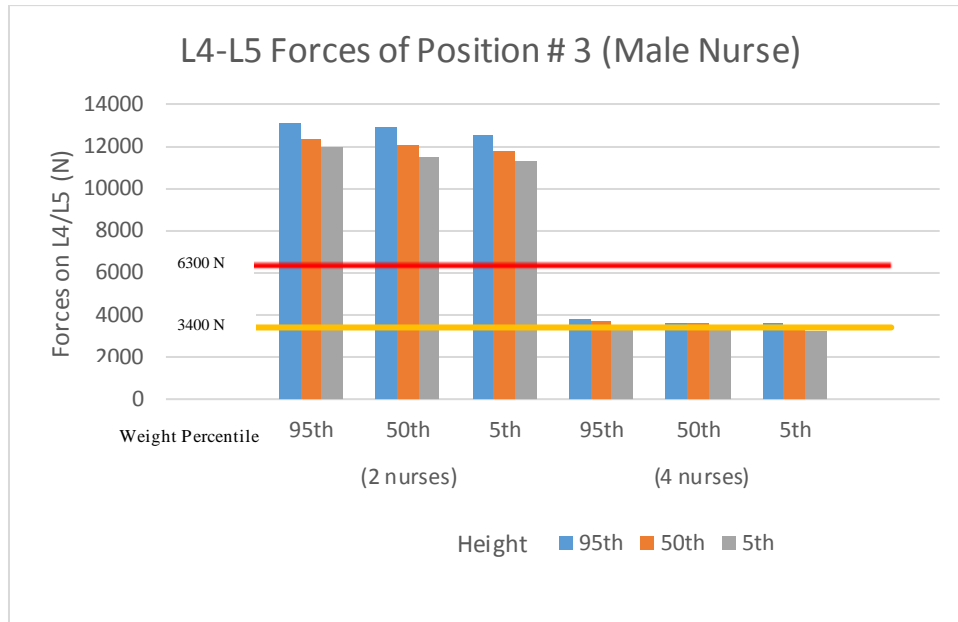


Figure 7. Lower back forces for P3 step in reposition procedure 2 nurses vs. 4 nurses

The improvements results show a decrease in force during P3. The risk reduced from high risk to all anthropometries, into little risk and no risk. However, for a safe handling only a 5<sup>th</sup> percentile weight with 5<sup>th</sup> or 50<sup>th</sup> percentile height male nurses should do the task to fulfill NIOSH requirements.

### 5.2 Lifting

For the lifting procedure, one nurse was added to assist in the procedure and it was effective in reducing the force and the risk. Figure 8 shows the result of risk level of allowing 3 nurses participating in the procedure instead of 2 nurses. It also shows the anthropometries of the nurses that will have no risk in participating in the lifting procedure of bariatric patient. For lifting task, any 3 male nurses can lift the patient except 95<sup>th</sup> weight and 95<sup>th</sup> percentile weight nurse as the LPA shows compression forces larger than 3400N.

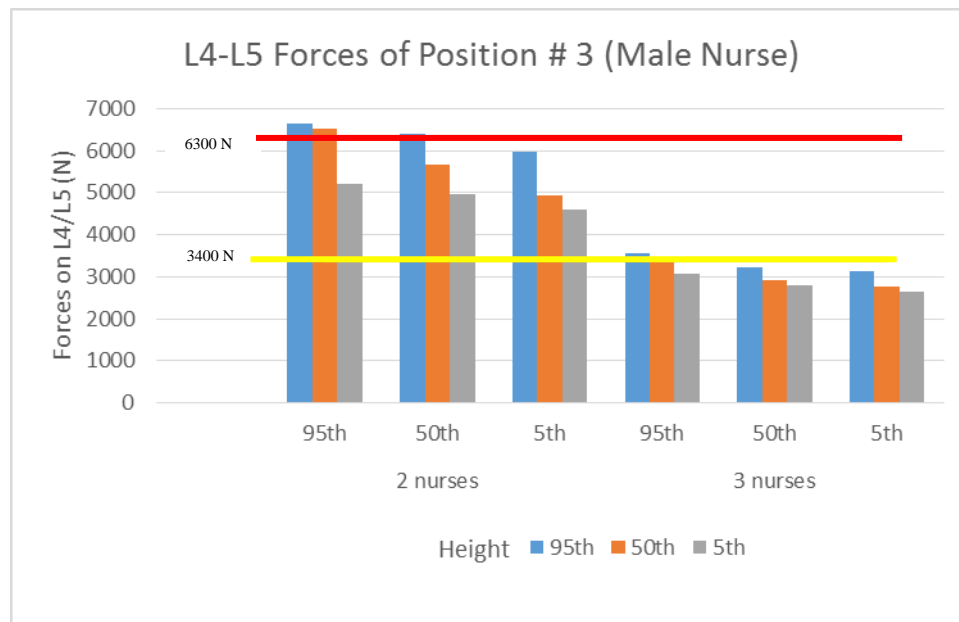


Figure 8. Lower back forces for P3 step in lifting procedure 2 nurses vs. 3 nurses

## 6. Conclusion

Patient handling tasks are physically demanding and usually performed under unfavorable conditions. There is a high rate of injuries caused by patient handling which affects the nurse's health and safety. In a local hospital in Kuwait, nurses complained of patient reposition and lifting procedure as a leading cause of lower back injuries. Digital human models were built for these tasks to assess the risk associated with patients reposition and lifting. The results show that there is a high risk associated with manual patient handling. Different scenarios were studied to determine the appropriate number of nurses to handle patients without exceeding the recommended NIOSH limit of 3400 N of lower back compression. For reposition task it was found that 4 nurses at least are needed with only a 5<sup>th</sup> percentile weight with 5<sup>th</sup> or 50<sup>th</sup> percentile height male nurses to do the task, if done by 4. Patient lifting needs only 3 nurses with any weight or Height percentile to do the task, only nurses of 95<sup>th</sup> weight and 95<sup>th</sup> height can do it.

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## Biography

**Lawrence Al-Fandi** is an Assistant Professor in the Department of Industrial Engineering at the American University of the Middle East in Kuwait. He earned his PhD in Industrial and Systems Engineering from Binghamton University, NY, USA, and his B.S. and M.S. in Industrial Engineering from University of Jordan, Jordan. His publications focus on business process improvement, Simulation, ergonomics, and Six Sigma applications. He has been leading or co-leading a wide spectrum of projects with local factories and hospitals in Kuwait that focus on applied research projects that can be broadly classified under (a) inventory systems, (b) quality assurance (c) enabling process excellence

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