

Ergonomic implementation of movement interventions in healthcare from the point of view of the physiotherapist

David Ravnik^{1,2,*}, Katarina Merše Lovrinčević³, & Václav Bittner⁴

¹ Department of Physiotherapy, Faculty of Health Sciences, University of Primorska, Izola/Isola d'Istria, Slovenia

² Faculty of Health and Social Sciences, Slovenj Gradec, Slovenia

³ High School of Forestry, Lumbering and Health, Postojna, Slovenia

⁴ Department of Mathematics, Faculty of Science, Humanities and Education, Technical University of Liberec, Liberec, Czech Republic

* Corresponding author: david.ravnik@fvz.upr.si

ABSTRACT

Introduction: Healthcare workers have a high prevalence of musculoskeletal problems, which are often associated with the physical demands of their work, especially with manual handling, lifting and helping patients with mobility. In this paper, we examined these interventions from the physiotherapist's point of view, mainly with the help of biomechanics, and proposed appropriate ergonomic approaches to reduce risks of musculoskeletal disorders.

Methods: We analysed two basic interventions: helping patients to sit over the edge of the bed (starting in the supine position) and helping them to stand up. To determine the safest and most effective methods, we used a combined approach of biomechanics and ergonomics, and we also considered the patient's cooperation in order to train independence and functionality. This approach has also been explained with the help of ergonomic principles.

Results: The optimization of assisting patients to sit over the edge of the bed emphasized minimal lifting, gradual execution, effective rotation of partial centres of gravity, patient activation, use of levers (to use gravity), and rotation instead of lifting. When helping patients to stand up, it is most optimal for the healthcare worker to stand next to the patient, ideally on the side where the patient has preserved better functionality. All the proposed methods have proven to be more ergonomically effective and safe, and allow the patient to gain more independence and functionality.

Discussion: By incorporating the principles of ergonomics and biomechanics, we can reduce the physical burdens of healthcare workers, which does not only improve the safety of healthcare providers, but also increases the safety and independence of patients. Our findings highlight the need to evaluate the relevance of traditional approaches to lifting and handling patients in healthcare.

Conclusion: Incorporation of optimized methods into patient mobility curricula for healthcare professionals is suggested. Policy changes that focus on reducing manual tasks and lifting and include ergonomic interventions can play a key role in reducing work-related musculoskeletal problems.

KEYWORDS

manual handling and lifting; ergonomics; biomechanics; movement interventions; health workers

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INTRODUCTION

In healthcare, interventions often involve physically moving and lifting patients, which has been proven to increase the risk of musculoskeletal issues (Oliveira, et al., 2015). The physical stress resulting from these activities is not only dependent on the mass of the object being moved but also on various other factors, such as leverage, forces and torques, physical condition, and the lifting techniques used (Cimolin, et al., 2016; Haddas, et al., 2016). The term “proper lifting” has been in use for over 100 years, yet traditional approaches to lifting and moving patients have long been criticized (Ravnik, et al., 2017; Ravnik, et al., 2022). Despite a reduction in musculoskeletal issues in heavy industries, these problems have not decreased among healthcare workers, especially nurses, partly due to the traditional educational model (Berman, et al., 2021; Jacob, et al., 2015; Rees Doyle & McCutcheon, 2015). Patient transfers are a significant factor contributing to musculoskeletal issues among healthcare workers, even though nurses spend less than 7% of their time on these activities (Fiedler, et al., 2012). The traditional method is still used in practice in 89% of cases (Ravnik, et al., 2022), highlighting the need for change. It has been proven that ergonomically correct work can significantly reduce musculoskeletal strain (Weißert-Horn, et al., 2014), which is why mechanical moving and lifting are recommended or even mandated by legislation in many countries (Edlich, et al., 2005). An approach that avoids unnecessary lifting has been shown to be highly effective in preventing musculoskeletal issues (Nelson & Fragala, 2004).

METHODS

The aim of this paper is to identify fundamental ergonomic principles and consequently outline the implementation steps for two specific movement interventions. These interventions include assisting a patient in sitting up from a lying position on the back to the edge of the bed and assisting a patient in standing up. The goal is to reduce musculoskeletal strain and work-related musculoskeletal problems among healthcare workers, as well as to promote greater patient independence.

The notion that movement interventions in healthcare can be a risk factor for musculoskeletal issues is not new (Ravnik, 2014). An innovative approach to assisting a patient in standing up was published in 2017 (Ravnik, et al., 2017), and a modified approach to assisting a patient in sitting up on the edge of the bed was introduced

in 2022 (Ravnik, et al., 2022). Both approaches were presented as part of a scientific conference in Slovakia in 2022 (Ravnik, et al., 2022) and a professional meeting of enterostomal nurses in Slovenia in 2024 (Ravnik, 2024). The fundamental requirement for the successful execution of both interventions is the appropriate preparation of both the patient and the healthcare worker. This preparation allows for greater patient activity and independence, as well as successful implementation of some basic ergonomic principles in practice.

Before presenting both approaches graphically, we were interested in the actual state of use of each approach among nursing students. We assessed the frequency of implementation of individual approaches to the intervention of sitting up the patient among nursing students of the Faculty of Health Sciences in Izola, Slovenia. Before the students were introduced to the novel approach, we were interested in how they would sit up the patient themselves. The data were collected through observation during the course of rehabilitation (first year nursing students, bachelor program) from 2017 to 2022. The three approaches observed were the traditional method (A section of Figure 1), its modification with the headboard bent by 25–40 degrees, and the novel approach presented in this article (B section of Figure 1). The results are presented in Table 1.

RESULTS

Table 1 presents the results on the frequency of choosing the implementation of an individual approach to sitting up the patient.

Table 1 Method of implementation of sitting up the patient preferred by nursing students (N = 200)

Traditional method	Modified method	Innovative approach
123	55	22
61.5%	27.5%	11%

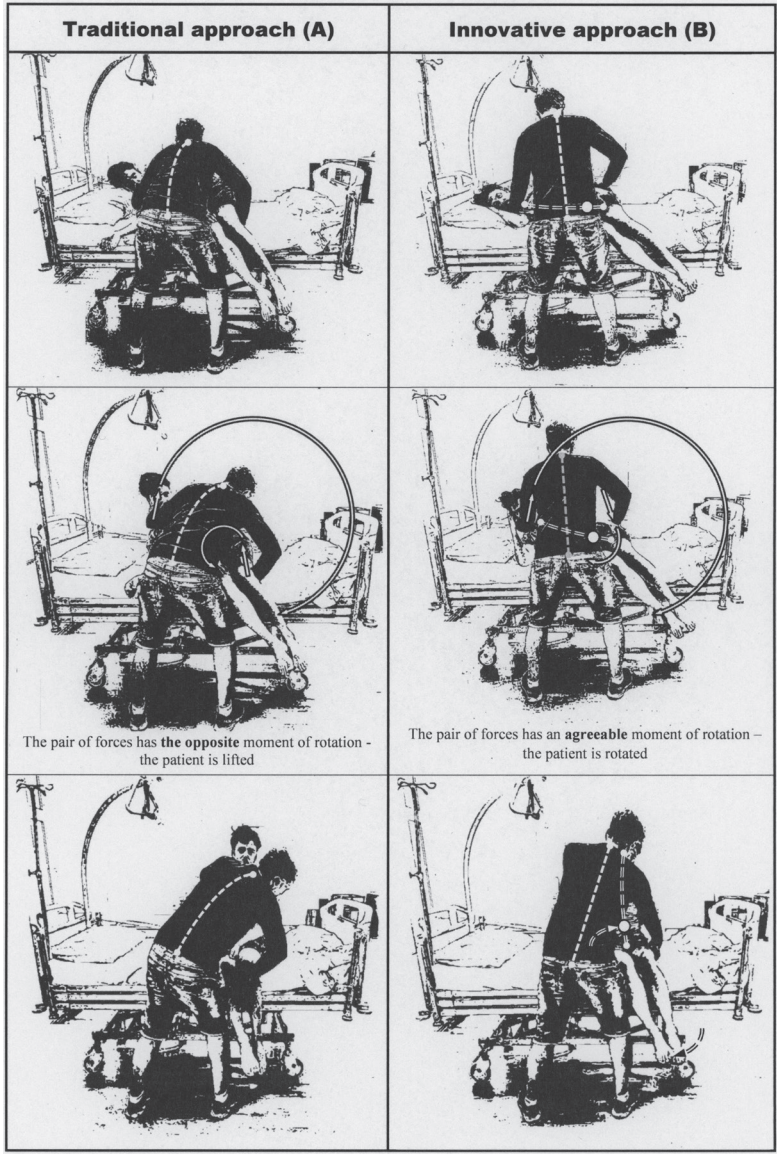
The implementation of sitting up the patient with the innovative approach was carried out by only 11% of students, who have all completed a medical high school programme (they have all been educated to the level of nursing assistant previously). All who chose this approach were part-time students, i.e. students with some practical experience.

Sitting on the edge of the bed starting from a lying position (Ravnik, et al., 2022; Ravnik, 2023)

The bed height for sitting must be such that the patient, when lying down, is 20 cm below the elbow height of the healthcare worker (ergonomic rule for heavy work) or so that the patient's pelvis is at the level of the healthcare worker's navel when sitting. *Steps* (refer to Figure 2 for assistance):

The patient is lying on their back.

1. The patient bends their legs – this creates leverage (the healthcare worker will then pull the patient's knees towards themselves, rotating the lower part of the torso).



The pair of forces has the **opposite** moment of rotation - the patient is lifted

The pair of forces has an **agreeable** moment of rotation - the patient is rotated

Figure 1 Assisted patient transition from supine to sitting (Ergonomic analysis – biomechanical model)

Legend:

	• Axis of the therapist's axial system
	• The direction of the therapist's force action on the patient's body segments and their rotational effect
	• Axis of the patient's axial system
	• Direction of movement of the patient's body segments (rotation and translation)
	• Patient's approximate COG position

2. The patient clasps one hand with the other and moves them to the side where the healthcare worker is standing (the healthcare worker helps by pulling the hands towards themselves via the patient's wrist, rotating the upper body).
3. The result of steps 1 and 2 is that the patient is turned onto their side. The patient is lying on their side.
1. The patient's legs are pulled over the edge of the bed so that they hang slightly off, creating leverage where gravity will help in sitting up the patient.
2. The healthcare worker places one hand under the patient's shoulders and the other on the iliac crest. This hand then pushes the pelvis downwards, achieving pelvis



Figure 2 Sitting on the Edge of the Bed (a – leg rotation, b – torso rotation, c – legs' weight, d – pressure on the pelvis, e – supporting force) (Ravnik, 2023)

rotation and consequently sitting up the patient. The hand on the shoulder only guides and minimally lifts (assisting rotation rather than directly lifting).

3. The result of steps 1 and 2 is that the patient is sitting on the edge of the bed (the bed is still in a high position).

Comparison of transition from lying to sitting

The essential differences between the traditional approach and the innovative approach are shown in Table 2.

Table 2 Differences between approaches A and B

Feature	Traditional approach (A)	Innovative approach (B)
Healthcare worker		
Spine	forward/deviated/rotated	mostly straight
Grip	under the legs; the latter are pulled and lifted over the edge of the bed	one hand under the shoulders, the other in the pelvic area
Pressure/force	simultaneously lifting the torso and lifting and pulling the legs over the edge. The pair of forces has the opposite moment of rotation – the patient is lifted	rotation of the COG by pressing the pelvis in the direction of rotation and a slight assistance in raising the trunk. The pair of forces has an agreeable moment of rotation – the patient is rotated
Work in planes	simultaneously in transverse and frontal	first in the transverse, then in the frontal
The center of attention	whole body	COG
Stability/balance	Medium	High
Consideration of ergonomics and safety	Medium	High
Patient		
Rotation to the side	passive (with the healthcare worker's help)	active (via a longer handle – a lever)
Legs over the edge	done by the healthcare worker	with bent legs, the higher leg pushes the one on the bed towards the edge
Trunk muscle activity	Medium	High
Consideration of independence and safety	Medium	High

Table 3 Argumentation for a different approach when assisting the patient from the supine to the sitting position

Argument	Question	Discussion
“Turn around independently or by using a lever over the knees and shoulders”	How do I achieve turning in bed with as little effort and as clear instructions as possible?	The lying patient bends his knees (this gives us a lever for rotating the pelvis to the side) and with one hand pulls the other arm towards the therapist (this gives us a lever for rotating the upper part of the torso)

Argument	Question	Discussion
“Put your feet over the edge of the bed”	How to get the weight of the legs to help when sitting down?	When lying on your side, the foot of the upper leg is behind the foot of the lower leg. When attempting to extend, the result is that both legs go over the edge and leverage is achieved
“Bed height high”	At what height of the bed should I perform sitting?	As it is a difficult job, the object of work (COG of the patient) must be kept at a height of 10–20 cm below elbow height
“Rotate the center of gravity (COG) of the load in the main direction – down – to the floor”	How do I achieve trunk lift with as little lifting as possible?	By pressing down on the guttural crest, we achieve COG rotation, which initiates the lifting of the trunk into a sitting position, while at the same time slightly assisting the moment of force over the shoulders in the direction of sitting

Standing up from the bed (Ravnik, et al., 2017)

The bed height for standing up must be such that the patient has both feet on the floor and knees bent at 90–100 degrees.

Steps (refer to Figure 3 for assistance):

The patient is sitting on the edge of the bed.

1. The patient has their feet on the floor and pulls them slightly under the bed – this moves the support surface closer to the projection of the center of gravity on the floor (COG) – the COG is otherwise located at the level of the second sacral vertebra, and its projection at this stage is near the heels on the floor.
2. The patient loads their feet, moves the torso forward and slightly upward, and straightens the knees – this transfers the COG over the support surface and the patient stands up. As long as the projection of the COG on the ground is within the support surface area, the patient will be stable.
3. The result of steps 1 and 2 is that the patient stands up.



Figure 3 Standing up from a sitting position (arrow – direction of COG transfer) (Ravnik, 2023)

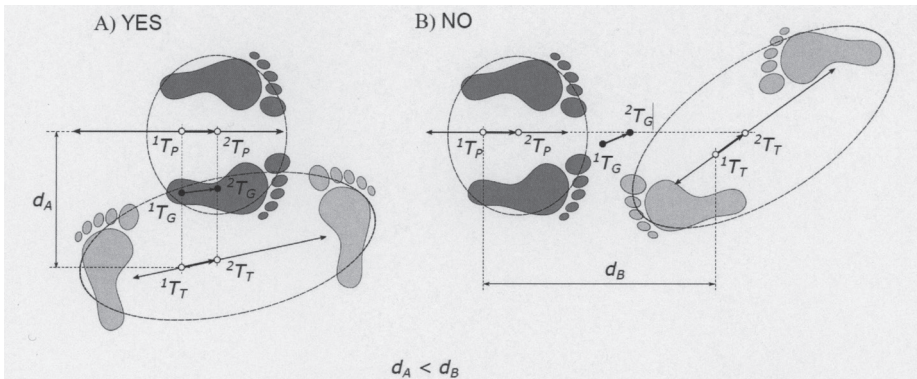


Figure 4 Foot orientation and movement of COGs (floor projection) (Ravnik, et al., 2017)

Legend:

Index 1 – initiating movement, index 2 – completion of movement,

Black feet – patient, grey feet – therapist

TP – projection of COG of the patient to the flatness of the floor

TT – projection of COG of the healthcare worker to the flatness of the floor

TG – projection of the common COG (patient and healthcare worker) to the flatness of the floor (approximately equal weight of both individuals)

dA , dB – distance of projection of COG of the patient and healthcare worker $dA < dB$

If a healthcare worker is assisting with standing up, they should stand next to the patient, grasping the patient's hand with a "thumb-to-thumb" grip with their outer hand, and placing their inner hand under the patient's shoulder (without gripping). The healthcare worker fixes the patient's foot and knee (the leg next to the healthcare worker) with their outer leg. When assisting with standing up, the healthcare worker only helps the patient move their COG forward and slightly upward.

Figure 4 presents the difference in force transmission depending on the position of the healthcare worker (whether he is standing in front of the patient or at his side – which is more optimal for controlling the transfer of COP above the feet and also from the point of view of weight transfer forward when standing up – greater functionality of the patient and more learning of independence).

Arrows indicate the direction of displacement of each projection of COG to the flatness of the floor.

Ovals approximately define the area where it is possible to approach individuals with relative stability.

DISCUSSION

Despite the traditional methods being taught based on the standard approaches to manual handling and lifting, these approaches often prove ineffective in reducing health issues (Nelson & Baptiste, 2004). Therefore, it is important to emphasize the significance of basic preparations for work, such as adjusting bed height, correct positioning of the assisting person, clear instructions for the patient, and proper execution of the procedure as described earlier in the article. When performing interventions, such as assisting a patient to sit on the edge of the bed, healthcare workers can choose to use traditional

methods or opt for an optimized or innovative approach, more commonly utilized by physiotherapists (Ravnik, et al., 2022; Ravnik, 2023). It is crucial for healthcare workers to be educated about the modern methods that can lead to better outcomes in reducing musculoskeletal loads and issues when working with patients. Given the high prevalence of musculoskeletal problems among healthcare workers, it would be sensible to carry out ergonomically inappropriate interventions only as slowly and thoughtfully as possible, relying heavily on patient assistance. Research indicates that employees with a history of back pain tend to perform lifts in a manner that is slower and more similar to a squat, compared to workers without such a history (Saraceni, et al., 2021).

During the transition of a patient from the lying to the sitting position, greater active participation from the patient is desirable, with minimal lifting from healthcare workers utilizing biomechanics, particularly COG rotation. In this scenario, the patient is facilitated in rotating COG on one side using the weight of their legs and activating trunk muscles in response to the pressure applied by the healthcare worker on the pelvis in a downward rotational direction on the other side. This contributes to a gradual transition into a sitting position.

In summary, both approaches can be illustrated with the example of picking up a rake, where the task is to “position the rake handle so we don’t need to bend over”. Traditionalists would achieve this by picking up the rake by bending over to grasp the handle and lift it (Figure 5a), whereas innovators would pick up the rake by stepping

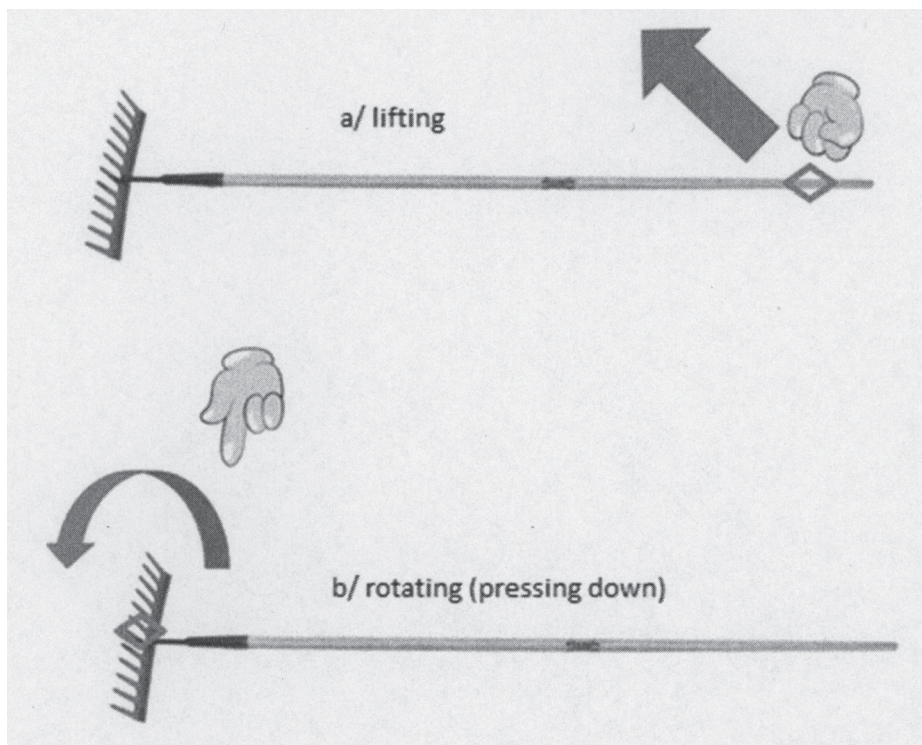


Figure 5 Lifting or pressing down (near-axis rotation) – same effect – diamond is the point of grip (a) or pressure (b)

on the head of the rake – pressing the latter into the ground (Figure 5b). In this second approach, we push downward and are not in a forced position. From an ergonomic perspective, the second approach is more effective because two different directions of force application create the same rotational effect.

Kamiya (2005) described the connection between their proposal for standing up and the movement of older patients. The same movement as proposed by Kamiya can be achieved with an approach where the healthcare worker stands next to the patient, similar to our approach. Trunk inclination additionally reduces the load on the knees during standing up (Fisher, et al., 1990), which is beneficial when assisting older adults with weaker leg strength. The described transition from a seated to a standing position mostly occurs without the use of aids. Literature mentions belts that are placed around the patient's hips to facilitate gripping by nurses (Gagnon, et al., 1988), although this activity is usually not performed by a single healthcare worker. In the 1990s, nurses began using kidney belts to protect the back during lifting, although there was no evidence supporting this approach (Wassell, et al., 2000). When preventing musculoskeletal problems, tools and devices such as mobile and ceiling lifts have proven effective (Yassi, et al., 2001). The use of a bed that allows lateral tilt (right/left) can reduce the risk when assisting patients in bed, as healthcare workers are not forced to lean over the bed and can have a better grip.

All educational institutions should prepare healthcare workers for the proper manual handling and lifting of patients. However, most nursing students continue to learn traditional techniques, despite the lack of evidence supporting their use in practice. Some of these techniques can even be dangerous for both the patient and the healthcare worker (Corlett, et al., 1993). Therefore, it is crucial to reduce manual lifting and use scientifically proven approaches. It is also important to establish good evaluation protocols, such as OWAS (Ovaco Working Posture Analysis System) for measuring physical stress (Engels, et al., 1998), and to include ergonomic programs in educational programs, collaborate with experts in physiotherapy and ergonomics, and implement programs to improve the working environment in healthcare institutions at all levels of education. In Slovenia, there are some practical educational programs that are part of legally mandated health promotion in the workplace and are compliant with current legislation (Ravnik, 2013; Ravnik & Kocjančič, 2015). On the other hand, the impact of physical fitness (conditioning, abilities) on work in healthcare and consequently on musculoskeletal problems should also be examined. Physical activity at work, especially appropriate physical conditioning, has been effective in preventing injuries in industry (Ravnik & Kocjančič, 2015) and in healthcare (Jakobsen, et al., 2015).

CONCLUSION

It is important for healthcare workers to develop good posture and physical fitness and to avoid unnecessary manual lifting, which can cause injuries. Proper education and practice are crucial, especially for nurses who need to be properly trained to avoid incorrect lifting techniques. It is necessary to reduce manual lifting using mechanical aids, also due to the aging working population. It would make sense to use similar approaches to analyze the majority of movement interventions in health care, which could result in reducing the workload of employees and also increasing the indepen-

dence of patients. It is clear from the paper that individual movement interventions can be carried out in several ways, and which is more optimal has been shown by recent research. Therefore, it is important to plan and prepare the working environment, the mutual arrangement, the force used or the device, if necessary, the use of an appropriate approach and, last but not least, the patient's activity in the direction of functionality should also be considered. These modified approaches should also be introduced into the education of health professionals and the curricula of healthcare schools.

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