Design and development of an ergonomic transfer lifter assistor from wheelchair to bed for patient under 50 kg

Chicha Bagu[1*], Hatimi Mudin[1], and Fethma M Nor[2]

[1]*Department of Mechanical Engineering, Polytechnic Kota Kinabalu, No. 4, Jalan Politeknik, KKIP Barat, Kota Kinabalu Industrial Park, Politeknik Kota Kinabalu, 88460 Kota Kinabalu, Sabah, Malaysia*

[2]*School of Design, Universiti Teknologi Brunei, Gadong BE1410, Brunei Darussalam*

[*]*Email: chicha@polikk.edu.my*

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Abstract

Moving patient by caregiver from bed to other places for the daily routine is challenging. However, caregiver faces difficulties when lifting patient from bed to wheelchair. The task requires excessive physical effort and often takes a considerable amount of time. Therefore, this study focused on the design and development of transfer lifter assistor to help caregiver move patient from bed to another place. The advantages of the innovation included the height adjustment, making patient more comfortable to sit on bed, and size adjustment of up to 3 and a half feet. The structure was mostly from steel and could be disassembled for storage purposes. The result showed that transfer lifter assistor performed effectively in lifting patient with a maximum weight of 50 kilograms, supporting one person at a time. This innovation had been successfully produced with cost-effectiveness, which could also be owned by everyone.

Keywords: *Wheelchair, back pain, transfer lifter, assistive devices, low-cost design.*

I. INTRODUCTION

Wheelchair is an excellent mobility aid, but transferring a patient from it can be challenging due to physical burden on caregiver and the increased risk of falls. The studies conducted by Al-Samawi &Awad [1] found that carrying heavy medical equipment and patient were the major causes of low back pain among caregiver. Ovayolu et al [2] found that performing certain nursing tasks without assistance or the use of supportive equipment increased the frequency and intensity of low back pain. In addition, nurses who reposition or lift patient without help are more expected to experience low back pain [3]. Previous studies have shown that manually transferring a disabled patient from bed to standard wheelchair is demanding and requires complex movements [4]. Caregiver needs to lift patient, reposition or make a turn from bed towards the direction of wheelchair, and safely seat the patient. Therefore, improving wheelchair design is essential to address the challenges faced during patient handling. The aim of this study is to develop a user-friendly device that eliminates the need for manual lifting when transferring a patient from bed to wheelchair. This simple transfer equipment is expected to promote the health of caregiver and reduce physical strain.

II. LITERATURE REVIEW

Table 1 shows several recent transfer lift wheelchair options available to users. However, most of the developed models are expensive and remain unaffordable for low-income families.

Table 1: Current market price for various transfer lift chairs

	
Rover Manual Transfer Lift wheelchair chair	Nursing Moving Commode Transfer Chair
RM 2,250.00	RM 2,238.40

	
RITZ Rehab Mover Transfer Lift Chair	RITZ rehab salvo electric lifting chair
RM 2,800.00	RM6,120.00

III. Design and Development

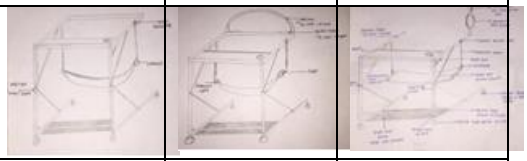
A. Design and Development

The concept design of transfer lifter assistor was based on the specification requirements from the customer. Manufacturing costs were also considered, allowing the products to be owned by the low-income group.

B. Idea Selection

The selection of transfer lifter assistor was based on the specification requirements from customer. The prototype was developed as a test for study purposes. Three ideas, as shown in Table 2, had been proposed, including design, cost, safety, ergonomic, and disassembly impacts. All the proposed designs would assist patient from bed to chair or vice versa.

Table 2: Idea selection

Criteria	1st Idea	2nd Idea	3rd Idea
Sketch			
Safety	Using wheel without lock. Not placing barriers that could support the head	Using wheel with lock. Placed barriers that could support the head	Using wheel with lock. Placed barriers that could support the head
Ergonomic Disassembly	Height was adjustable. All connections were welded and could not be disassembled.	Height was adjustable. Only the rear barrier could be disassembled.	Height was adjustable. The rear barrier was easy to put in and disassemble. Legs could be disassembled for storage purposes.

C. Concept Development

Transfer lifter assistor shown in Figure 1 was designed for safe assistance when transferring patient, which was a heavy burden for caregiver. The assistor consisted of three components, namely seat, front assist bar, and back barrier. In addition, the characteristics of transfer lifter assistor included a U-shape frame, allowing attachment to bed or toilet, and a detachable back barrier. Through these features, patient could transfer from one place to another in a sitting position.

Figure 1. Transfer Lifter Assistor

Figure 2 (a) showed that patient did not need to stand when moving from bed or toilet seat to transfer lifter assistor. Caregiver could assist patient by gently bending at the waist to guide onto the device. This process eliminated the need for caregiver to lift the patient manually.

The innovation proved to be more beneficial for caregiver compared to a standard wheelchair. As shown in Figure 2(b), when using an ordinary wheelchair, caregiver often experience back pain from lifting and assisting patient with pivot turns. Therefore, caregiver should exercise caution when helping patient stand to prevent injuries during transfers.

D. Function and Operation Method

A single caregiver could operate the transfer lifter assistor to lift patient. The product was a designed for wheelchair users who were able to maintain a seated position. It allowed the caregiver to transfer a disabled person easily and safely between wheelchair, bed, or other locations without manual lifting. The operating instructions for the transfer lifting assistor were shown in Figure 2(a) as follows. The patient was asked to sit on bed, then the caregiver adjusted the position of the patient toward transfer lifter assistor. After this process, the buttocks of patient were positioned on the chair, and finally, the necessary posture adjustment were made. This completed the transfer from bed to transfer lifter assistor. The device was easy to operate and did not require high skills to handle.

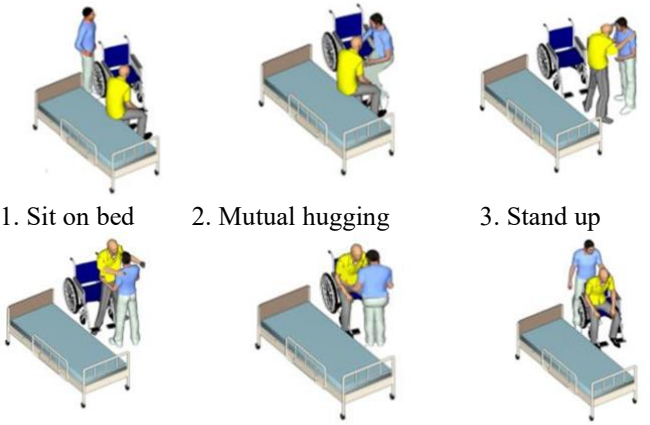
1. Sit on bed

2. Adjust the position of patient

3. Sit on transfer lifter

4. Final posture adjustment

(a) Assisting with transfer lifter assistor



1. Sit on bed 2. Mutual hugging 3. Stand up

4. Pivot turning 5. Sit on chair 6. Final posture

(b) Assisting with an ordinary wheelchair [5]

Figure 2. Assisting transfer from bed to transfer lifter or ordinary wheelchair.

Figure 2 showed that an ordinary wheelchair was demanding with complex movement to transfer patient. Caregiver handling the task with an ordinary wheelchair was classified into six steps, namely sit on bed, mutual hugging, stand up, pivot turning, sit on wheelchair, and final posture adjustment. Meanwhile, using transfer lifter assistor was classified into four steps, namely sit on bed, adjust the position of patient, sit on transfer lifter assistor, and final posture adjustment. Through this process, handling tasks decreased the time, complexity of transfer, and physical load during transfer.

E. Time for Assistance

During the analysis, the person who acted as caregiver had no medical history, and experience with nursing care could affect the assisting actions. On the other hand, the person who played the role of patient was assisted in relaxing the lower limbs. The actor was fully informed about the objective of the experiment.

IV. Result

A. Patient transfer skill

Burdof et al. [6] estimated the impact of lifting devices on the prevention of low back pain and musculoskeletal disorder injury claims. The study observed that the complete elimination of manual lifting of patient would reduce the low back pain to 31.4% and musculoskeletal disorder injury claims from 4.3 per 100 work-years. Lifting patient using transfer lifter assistor eliminated the mutual hugging, standing up, and pivot turning, which required lifting. Therefore, the device would reduce back pain and musculoskeletal disorder injury claims.

B. Time for assistance

The average time necessary to assist transfer from bed to wheelchair was 32 ± 54 seconds. The average time to transfer from wheelchair to bed was 26 ± 37 seconds. Motegi et al [7] explained that mean task times for transfer from bed to wheelchair were 140.7±61.3 seconds. Mean task time from wheelchair to bed was 129.8±52.0 seconds using an ordinary wheelchair. As a result, using the lifter assistor reduced transfer time by 77% from bed to wheelchair and 80% from wheelchair to bed.

C. Cost

The manufacturing cost and market price for the product were reasonable and affordable. The product could be marketed at RM 600, which was 70% to 90% reduction compared to the current lifter. Therefore, this lifter could be owned by all wheelchair users regardless of cost.

V. Conclusion

In conclusion, the objective of this study was achieved successfully, as the transfer lifter assistor enabled patient to be moved directly from a sitting position to a frontal position. Indirectly, transfer lifter assistor method decreased workplace injuries and lower back pain, which was an added advantage for healthcare workers. The advancement would also inspire wide-range deployment to assist wheelchair users, specifically in developing countries.

Future studies should improve transfer lifter assistor for better practical application, mechanical strength, stability, design, and be adaptable for both indoors as well as outdoors use. In addition, mechanical strength should be improved for the usage by all groups, with adjustable height points and more interesting shapes to refine the design.

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