

Multi-Fowler Techno Bed: A Solution for Pressure Ulcer Patients

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Abstract: Nowadays, pressure ulcers or decubitus ulcers occur across the spectrum of health care settings. Pressure ulcers are localized injuries of dermal tissues caused by poor blood supply due to concentrated pressure on susceptible tissues. The most expedient method for reducing pressure is to turn and position the patient frequently, advisable of 2-hour interval. This requires the health-care workers', especially nurses or physiotherapists' effort to mobilize them. The highest incidence is actually in the hospital, while the highest prevalence is in long-term care facilities. Pressure ulcers are increasingly being used as indicator of poor-quality care. Failure of nursing care is blamed for most pressure ulcers in both hospitals and nursing homes. This was not because of the staff nurse refused to mobilize the patients, but sometimes this is about the insufficiency of health-care workforce to make the big-sized ill patients move their extremities on bed in the hospitals. Thus, this paper discusses on a new product called "Multi-Fowler Techno Bed" as the solution of this pressure injury by pressure-relieving technology.

Keywords: Pressure ulcer; decubitus ulcer; musculoskeletal disorders; pressure relieve; multi-fowler bed.

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INTRODUCTION

Pressure ulcers are defined as localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear (Mallah, Nassar, & Kurdahi Badr). Mobility and activity are the main predictors of pressure ulcer development that are greatly impaired in patients with major trauma (Rafiei et al., 2014) such as spinal cord injuries (Thomas, 2001). This is because trauma patients usually remain immobile for long periods of time in the emergency department prior to their admission to a ward. Elderly especially those with hip fractures are another high-risk group whom susceptible to pressure ulcers (Rafiei et al., 2014). The incidence of pressure ulcers in hospitalized patients ranges from 3% to 30% whereas most estimates centering around 9% to 13% (Thomas, 2001). Pressure ulcers are reasonably preventable and most hospitals in developed countries have established protocols and interventions for preventing or lessening the severity of this problem (Mallah et al.). The prevention strategies include recognizing the risk, decreasing the effects of pressure, assessing nutritional status, avoiding excessive bed rest, and preserving the integrity of the skin. The best method for reducing pressure is to turn and position the patient frequently in 2-hour interval. However, turning the patient to relieve pressure may be difficult to achieve because this requires the best nursing efforts, and is very costly. Healthcare workers in particular have shown to experience higher rates of musculoskeletal disorders (MSDs) than those in construction, mining, and manufacturing (Daraiseh, Cronin, Davis, Shell, & Karwowski, 2010). Among healthcare workers, evidence shows that nurses in particular are at risk for MSDs. One of the causes is positioning the patients who are bed ridden. This task requires great workload of the nurse to position, turn or transfer the patients for approximately every 2 hours. If there are 2 or 3 persons to assist, there should be no problem. However, if there is only one person in-charge (nurse or physical therapist), there may be a big problem for that person to

handle especially a big-sized patient. Extra effort is required to accomplish this task which later may lead to any musculoskeletal symptoms. Thus, a prevention strategy is required to reduce the prevalence of pressure ulcers and also MSDs among health care workers especially nurses and physical therapists. Instead of positioning, a pressure-reducing device is recommended to be invented as the prevention strategy in solving these problems. Therefore, this paper suggests a conceptual product to overcome this issue.

PROBLEM STATEMENT

Nowadays, pressure ulcers or decubitus ulcers occur across the spectrum of health care settings. Pressure ulcers are localized injuries of dermal tissues caused by poor blood supply due to concentrated pressure on susceptible tissues. The most expedient method for reducing pressure is to turn and position the patient frequently, advisable of 2-hour interval. This requires the health-care workers', especially nurses or physiotherapists' effort to mobilize them. The highest incidence is actually in the hospital, while the highest prevalence is in long-term care facilities. Pressure ulcers are increasingly being used as indicator of poor-quality care. Failure of nursing care is blamed for most pressure ulcers in both hospitals and nursing homes. This was not because of the staff nurse refused to mobilize the patients, but sometimes this is about the insufficiency of health-care workforce to make the big-sized ill patients move their extremities on bed in the hospitals. Thus, this paper discusses on a new product called "Multi-Fowler Techno Bed" as the solution of this pressure injury by pressure-relieving technology.

PRODUCT DESCRIPTION

This product will use electrical power to be operated. However, in case of electrical power is off, automatic battery backup solution is provided. In addition, there will be extensive features added which are one-button dining chair, bubble air mattress, multi-plane body rotation, bed treadmill and automatic bed sitting.

The main application of the multi-plane body rotation bed is to prevent bed sore/ulcer in prolonged bedridden patient. The user could program this application to stop at any degree to meet clinical or specific comfort and positioning that they required. The Multi Fowler Techno Bed's rotation system is a sophisticated mechanical device that ensures accuracy and consistency of turning. The product is equipped with head and leg elevation system that allows the user to pick any different positions to suit his or her individual needs or preferences. According to Zhang et al (2001), the perfusion pressure and muscle blood flow can be reduced by do the leg elevation including the sensory dysfunction and muscular weakness. In addition, it facilitates the patient to do bed mobility automatically. The height can be variable which high and low that the positioning of the platform at any height from 22 inches (wheelchair transfer height) up to 34 inches off the ground (at the level of the top of the mattress).

Approximately 80% of care-giver injuries involve back, neck, and shoulder problems due to result of moving, repositioning or otherwise caring for patients. Thus, this feature is extremely helpful when moving the user to or from wheelchair or other item of medical equipment and is, most certainly, of significant benefit to caregivers who can adjust the platform height to provide for comfortable and safe administration of care. This bed can transform from normal to leisure chair. Thus, the medical centres do not have to buy another leisure chair. This can reduce the spaces and cost. The mattress bubble is made up by synthetic fibres. It is a series of connected cushions. The fibres may be silicone-coated, or formed into balls to reduce shear and friction. Air may be able to circulate freely around the fibres, reducing moisture accumulation and temperature can be maintaining around the patient's skin. The pressure will be alternate by cyclical inflation and deflation of air cells over a short period of time. This can relieve relieving pressure and creating a pressure gradient that enhances blood flow. It is lightweight, compact air pump providing alternating pressure of 40-90 MmHg (\pm MmHg). This bubble pad is suitable for patients who are at high risk for developing bed sore.

The function of the bed treadmill is to adjust and shift the patient in bed upward and downward before changing into another position. This can reduce the human workforce by using the controllable operating belt on the mattress. The operating belt is made up of orthopedic belt. It is a thick belt that can be rolled upward or downward to reposition the patients and it also can cushion the body weight of the patient. This belt is thicker, safer and comfort compared to standard belt as it can protect the spine. The last and but not least is one button dining chair. It is special design located at the side of the bed. This dining chair can be used either in long sitting or leisure chair. It can be folded and had one angel adjustable from 0 degree to 90 degree. The table top is laminated and the body is made up of powder coated steel which help to provide stability.

MECHANISM

Motor

Electric linear actuator is used for this product. The linear actuators are used to move an object or apply force in a straight line which can be divided into two types, single acting cylinders and double acting cylinder (Darbyshire, 2008). A linear actuator is an electric DC (direct current) motor that converts rotational motion into a linear motion (Warren et al, 2009). The Acme threaded rod or other screw drive mechanism are usually used meanwhile these motors are suitable for vertically lifting loads or moving an object back and forth (Warren et al, 2009). The power rating of the motor is determined by the power of the actuator that helps to drive it and usually rated by the maximum load capacity in pounds that the actuator can lift (Warren et al, 2009). Swapping the polarity of the wires can make the motor spin in the opposite direction as it is the simplest motor to power which apply a positive signal to one wire and a negative signal to the other (Warren et al, 2009). The spinning of the motor will be faster if the voltage is higher. Additionally, the speed of the motor is dependent on the positive supply voltage level (Warren et al, 2009).

Bed Treadmill

This bed treadmill is placed on the mechanical rotating base. The rotation of platform along orthopedic belt and user is lying under the mechanical rotating base covered by the mattress. The rotation of the orthopedic belt is carried by the gearbox and AC (alternating current) motor. A typical manual orthopedic belt passively rotates upward as the user shifts to upward on its surface. This orthopaedic belt is an adaptive, non-motorized, movement of treadmill giving full sense of stability.

Automatic Battery Backup

The Multi Fowler Techno Bed is powered by ICL 7673 which is a monolithic CMOS battery back-up circuit that has speciality on conventional means of switching to a backing supply (Lakshminarayanan, 1995). It is a low cost solution for the switching of systems between two power supplies which are main and battery backup (Lakshminarayanan, 1995). It helps to keep alive battery power switching (Lakshminarayanan, 1995). The current consumption of this circuit is low, while the operating voltage range is wider (Lakshminarayanan, 1995). The leakage between inputs is also low and logic outputs can be used to indicate which supply is connected (Lakshminarayanan, 1995). Besides, the logic outputs can increase the power switching capability of the circuit by driving external PNP transistors (Lakshminarayanan, 1995). A complete low power AC to regulated DC system can be implemented using the ICL 7673 and ICL 7663S micro power voltage regulator as shown in Figure 1 (Lakshminarayanan, 1995).

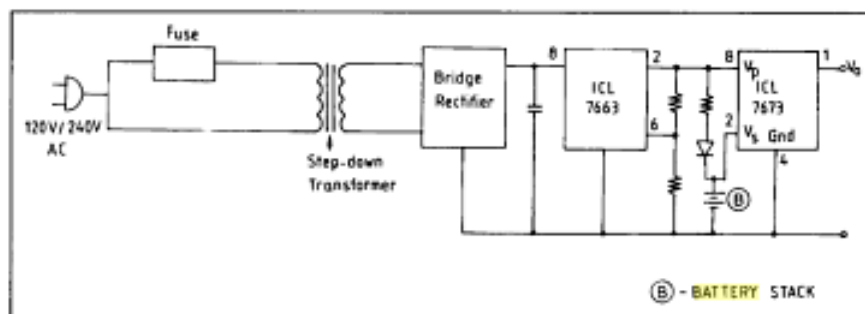


Figure 1: Power Supply

Multiple Rotation Bed

The product is primarily for the elderly, multiple rotation bed is added. Prolonged bed rest and immobilization inevitably lead to complications. Such complications are much easier to prevent than to treat. Musculoskeletal complications include loss of muscle strength and endurance, contractures and soft tissue changes, disuse osteoporosis, and degenerative joint disease. Cardiovascular complications include an increased heart rate, reduced cardiac reserve, orthostatic hypotension, and venous thromboembolism (Dittmier & Teasell, 1993). Thus these movements can help to relieve pressure, stimulate the body, improve circulation, and prevent problems associated with immobility. The limited rotation hydraulic motor can help to provide rotary output motion over a limited angle which has greater instantaneous torque (Doddannavar et al, 2005). This motor can help to reduce the space and only requires simple mountings (Doddannavar et al, 2005). These rotary motors consist of a chamber that

containing fluids (Doddannavar et al, 2005). A movable surface is connected to an output to produce the motion and it against the fluid acts (Doddannavar et al, 2005). It available with working pressure up to 350 kg/cm² and angle of rotation is maximum about 100 degree (Doddannavar et al, 2005).

The force on the vane equals pressure times the vane surface area which is given by:

$$F = P \times A$$

$$= P(R_v - R_r)L$$

The torque equals the vane force times the mean radius of the vane. This is given by:

$$T = P(R_v - R_r)L \left\{ \frac{(R_v + R_r)}{2} \right\}$$

On rearranging, the equation can be written as:

$$T = \left\{ \frac{PL}{2} \right\} (R_v^2 - R_r^2)$$

Volumetric displacement (V_d) is given by

$$V_d = \pi (R_v^2 - R_r^2) L$$

Combining the above two equations, we get

$$T = \frac{(PV_d)}{6.28}$$

Figure 2: Torque capacity equation

It is observed from the above equation(Figure 2) that torque capacity can be increased either by increasing the pressure or by increasing the volumetric displacement or both. The various applications of rotary type limited rotation motors are (Figure 3) (Doddannavar et al, 2005)

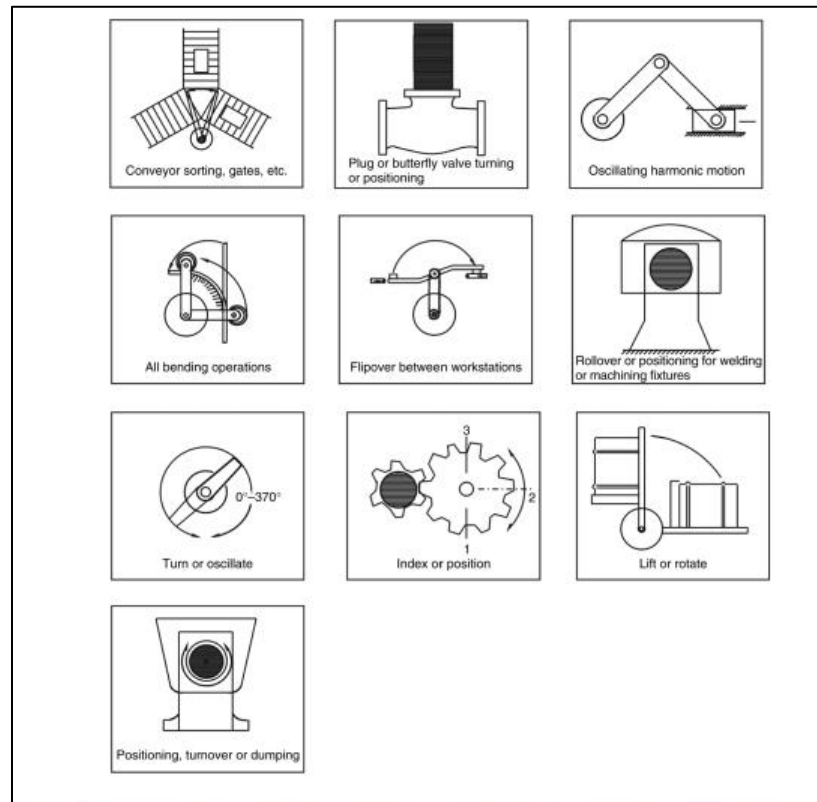


Figure 3: Application of limited rotation hydraulic motor

Thus, the Multi Fowler Techno Bed has a 60° range of rotation - 30° left and 30° right- from the horizontal position. The bed can be programmed to stay in any of the positions (left, right or center) for a time period from 1 minute to 4 hours. Each position can have a different time setting, allowing for a totally adjustable schedule to suit the user. For example, the user could move to 20 degrees on the left side for 2 hour, then 30 minutes at center (horizontal), then to the right side to 27 degrees for 2 hours. The schedule would then repeat through the night. Besides, the bed can change the height of the pallet, the inclination angle of bed rest segment and thigh rest segment and the angle of longitudinal and lateral tilt. It can resolve the problem of regularly turning over the patient with pulmonary infection. It also provides better drainage after operation.

Bubble Mattress

According to Bae et al (2014) the air mattress was the most effective in prevention a decubitus ulcer. The alternating pressure mattress consists of cellular air mattress connected to an electric air pump (Webste, 1991). The mattress consists two sets of tubular air cells that helps to alternately inflated and deflated (Webste, 1991). When first set of cells inflates, the second set will remains deflated then the second set inflates until both sets of cells are full and finally the first set deflates (Webste, 1991). It varies from 2 to 6 min and time switch help to control it (Webste, 1991)This cycle will work automatically repeat thus no part of the body is under constant pressure (Webste, 1991). The warning lights can be easily seen where the unit can be suspended at the foot of the bed (Webste, 1991). Before placing the patient on it, it is better to allow the mattress to inflate fully (Webste, 1991). A low pressure can be recognized if the red warning light does not go off within 10 to 45 minutes and the mattress need to be check (Webste, 1991).

SKETCHES ON THE PRODUCT

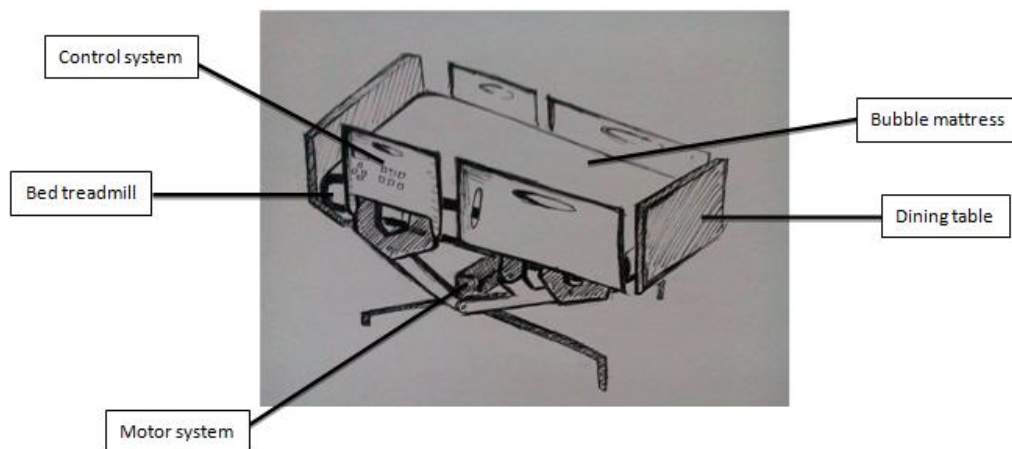


Figure 4: The Multi-Fowler Techno Bed

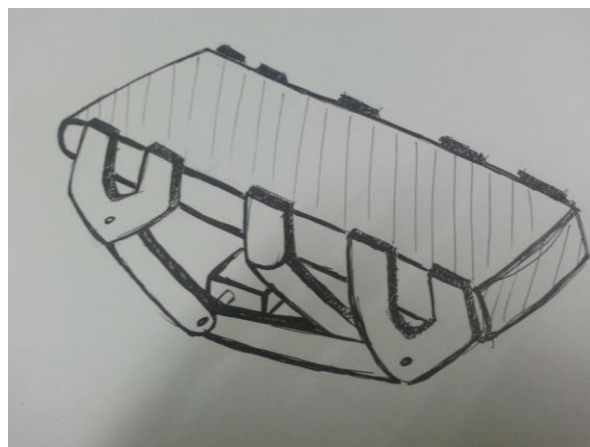


Figure 5: Bed Treadmill

BENEFITS OF MULTI-FOWLER TECHNO BED

1. Cost -effective :
 - 3 in 1 product (can be a bed or chair at the same time, together with the dining table)
2. Time and energy saver :
 - Only require one person to handle the patient.
 - Need lesser time to complete the task of positioning the patient.
 - Reduce manual handling and manpower
3. Lessen workload :
 - Able to manage many patients efficiently in limited time, space and number of staff
4. Minimize the risk of getting musculoskeletal disease among the clinician such as back pain.
 - Less of manual shifting, lifting, positioning and transferring assisted by automatic and controlled technology.
 - No prolonged bending of trunk, muscle strain and fatigue.
5. Increase patient comfort level by minimum touch and movement done by the clinician.
6. No risk of fall in order to transfer patient from bed to chair because the bed itself can transform into a chair.
7. Prevent further complication of bed rest/bed ridden such as circulation problem, thrombosis, reduces respiratory and lung function and bed sore.

CONCLUSION

The product concept of Multi-Fowler Techno Bed is designed to assist both the patients that are bed-ridden as well as the workers at the health care. The product could prevent the risk of bed-ridden patients from having pressure ulcers as well as the possibility of health care workers of having musculoskeletal disorders (MSDs). Multi-Fowler Techno Bed acts as a prevention strategy is required to reduce the prevalence of pressure ulcers and also MSDs among health care workers especially nurses and physical therapists.

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