The Strategy to Encourage the Bed Ridden Paraplegic Patient to Keep Fit at Home with the Development of Exercise Machine

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Abstract: Major drawbacks in caring for patients with physical limitations is that the conventional machines being used in most hospitals look like cages and the features and functions are not convenient for the user at home. As a result, the bed ridden paraplegic patients are unable to use the machines contently. The aim of this research is to show a solution to caring for bed ridden paraplegic patients, in order for them to keep fit at home, and to develop the exercise machine based on the disabled patients’ needs—focusing on, full function, strength, safety and its practical usage. The method of study consists of five steps as follows: (1) home visiting for collecting general data, (2) checking the patient’s ability and surveying patient’s requirement, (3) setting ultimate goals from multi-professionals including family physician, rehabilitation doctor, physiotherapist, nurses and engineers, (4) designing the machine using software and building the prototype, and (5) testing a machine at the patient’s home. The result of satisfaction after re-strengthening for a month was compared, at different times, between two disabled male patients of different ages and level of spine injury using two different types of exercise machines: MODEL1 and 2. One solution in dealing with health problems of the bed ridden paraplegic patients is a well-developed exercise programme from the multidisciplinary team. This helps the patients to exercise as suggested by diet, mental health support, as well as, exercise equipment which can provide many other benefits to bed ridden paraplegic patients. Moreover, with the development of the exercise machine, corrects inequality in health for handicap patients, specifically to tantamount with normal patients.

Key words: Inequality in health, exercise machine, paralysed patients.

1. Introduction

The burden of caring for paraplegic patients is a crucial issue in global health care systems, this a well-designed programme from the multidisciplinary team which can be used to improve their quality of life. In this globalised era, there is a variety of equipment to assist these patients to live happy life; these patients require special care in healthcare knowledge, as well as, emotional and social support.
A majority of paraplegic patients are bedbound with limited physical activity, so their muscle mass decreases, joints stiffen, and they develop pressure sores. Often, obesity can occur through a lack of physical movement and an unbalanced diet, consequently, causing weight gain and obesity. These complications may be decreased by an aerobic exercise programme with a more appropriate exercise machine. Indeed, a suitable exercise machine is an essential rehabilitation apparatus to the disabled people. This research will present the situation of body training facilities for paraplegic patients, the physical and mental health problems that result from this, present material and methods of the exercise machine. The results of which will be discussed hereafter. Additional, and as a solution, a proposal of a well-developed exercise programme, followed by the implications and evaluation of the proposed solution.

1.1 Situation

On the whole, it is difficult for people with physical disabilities to access physical training facilities such as a gym, playground, or swimming pool. It makes them feel as if they do not belong in society, therefore, they do not want to go outside the home. These feelings impact their mental and physical health; for example, being unhappy with low self-esteem leads to low motivation which reflects on their physical activities. The access to healthcare service among rural residents in Louisiana, shows that people with physical disabilities faced several barriers due to lack of health care knowledge, the limitations of medical care, and a shortage of rehabilitation devices [1]. It means that healthcare providers are not well-organised in the healthcare system, so this increases inequality in health provisions for disabled patients. For example, patients from low economic backgrounds cannot afford suitable apparatus or fitness equipment because of a low income. This situation leads to the problem faced by physically disabled patients, particularly bed ridden paraplegic patients. However, there was a conventional tool for rehabilitation which was used in hospitals but is not suitable for the home, it was called, the Universal Cage for Physical Improvement: the caregiver uses a wheel and string device for patient’s body training at home, because they cannot take the patient to the hospital and use the convenient rehabilitation tools as shown in Fig. 1.

1.2 Problem

Paraplegic patients may develop additional physical and mental issues due to inequality in health care. Firstly, pressure sore and joints stiffness can happen in bed ridden paraplegic patients. Moreover, they are sedentary individuals often develop obesity due to immobility and poor diets. That is to say, spinal cord injury results in a number of problems – decreased muscle function and sensation, and effects on cardiac function in exercise [2]. This decreased muscle function and sensation impairs training because there is no nerve supply to the muscles, therefore reducing the amount of exercise each patient can endure. This, coupled with poor diet contributes to obesity, cardiovascular disease, and other associated issues. Secondly, paraplegic patients also experience depression or feelings of isolation when bed ridden and separated from social interactions. Individuals may leave home to manage a depressed mood, but return home when pain and fatigue increases [3]. Yet, paraplegic patients always prefer staying in their beds because they feel comfortable and do not want to be a burden to caregivers. This means that if bed ridden paraplegic patients do not go outside their home, they may suffer from depression. Thus, providing care for these patients is not just to focus on physical activities, but a focus on emotional care too. Body and mind connection is a cause and effect chain. There has not yet been a perfect solution to deal with these problems, but the innovation of a holistic approach might be helpful.
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Fig. 1 A comparison between the rehabilitation equipment at the hospital and at home.
(A) Illustrates the universal cage for physical improvement model is a conventional tool for rehabilitation in the hospital; (B) illustrates a wheel and string device for training the patient’s body at home.

2. Materials and Methods

Researchers have provided solutions which encourage disabled people to keep fit at home and are integrated with an exercise machine—motivation and an attractive environment can be defined as a holistic approach. It was composed of (1) including a reduced carbohydrate diet, the prescription of exercise for weight control, by doing mild to moderate physical activity for 30 minutes per day and at least 5 days a week, (2) the motivation and special support from family members to do regular exercise, (3) a manual physiotherapy programme and (4) development of the exercise machine. Therefore, a healthy setting needs a well-developed exercise programme from a multidisciplinary team because it needs a particular collaboration. A multidisciplinary team composed of a family physician, a rehabilitation doctor, a physiotherapist, nurses, engineers and in particular, a Thai family doctor who not only works in the hospital but also visits the patient at home. Along with the bed ridden paraplegic patient, they discussed key drawbacks regarding exercise machine MODEL-1 at the patient’s home. For example, the base of the apparatus obstructed the mobile table over the bed. This was due to its wheel being inserted under the bed, and its large structure of aluminum not being convenient for the caregivers, which led to the creation of exercise machine MODEL-2. The method of study consists of five steps as follows:

(1) Home visiting for collecting general data after brainstorm the ideas as shown in Fig. 2.
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Fig. 2 Developers planned a more suitable structure supported through engaging in discussion with some paralysed patient during home visit care.

Fig. 3 Developers demonstrated MODEL-1’s functions to physical disabled before design MODEL-2.

(2) Checking the patient’s ability and surveying people with physical disability requirement before design MODEL-2 as shown in Fig. 3.

(3) Setting ultimate goals from multi-professionals including physicians, physiotherapist, nurses and engineers to solve the problems of the exercise machine MODEL-1 which needs double rails installing on the floor for sliding because this obstructs the caregivers, and healthcare providers in accessing the patients, especially the mobile table over the bed which requires its wheels to be inserted under the bed as shown in Fig. 4.

(4) Designing the machine using software and building the prototype as shown in Fig. 5.
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Fig. 4 The major drawback of the exercise machine for bed ridden paraplegic patient MODEL 1. This pointed the goal of function limitation of the previous exercise machine.

Fig. 5 Example prototype of the exercise machine for bed ridden paraplegic patient MODEL-2.

(5) Testing a machine at the patient’s home as shown in Fig. 6.

The structure of the exercise machine is made of an aluminium X-Frame. The design of exercise machine for bed ridden paraplegic patient MODEL 2 was developed from the exercise machine for bed ridden paraplegic patient MODEL 1. Comparison between the details of exercise machine MODEL-1 is shown in Fig. 7 and MODEL-2 is shown in Fig. 8.

To improve the machine’s utilization, the research team decided to reduce the size of its frame to 900 × 2000 mm. Also, the size of aluminium profile was reduced to 40 × 40 mm. The exercise machine is mainly composed of two parts:
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Fig. 6  Developer’s exercise machine MODEL-2 for bed ridden paralysed patients’ home usage.

Fig. 7  MODEL 1: Aluminium profile 40 × 90 mm. The size of exercise machine MODEL-1: 2400 × 1500 mm.

Fig. 8  MODEL 2: Aluminium profile 40 × 40 mm. The size of the exercise machine MODEL-2: 900 × 2000 mm. Suitable for bed size 990 mm in width, 2022 mm in length and 330 mm in height from floor to base of the bed.
(1) The base frame in Fig. 9, designing the sliding mechanism in Fig. 10, a set of sliding mechanisms was installed under the bed frame and on the adjustable bed legs as Fig. 11 shows. As a result, there is no bed rail to obstruct access to the patients and it is easy to clean the floor as Fig. 12. The upper and lower rails were fixed at the edge of the patient’s bed and reels were installed on both rails, to allow travel from one end to the other end as in Fig. 13. The research team tested the movement of the exercise machine and the result showed it to be smooth with only a rare shake; it can also be used by the patient with a weight up to 200 kg.

(2) The exercise set was made of the u-shape aluminium beam and exercise gadgets such as resistant band fitness. As the reels move on the rail, the aluminium beam moved along as Fig. 14 shows.

The particular collaboration for setting a well-developed exercise programme is not only focused on the development of the exercise machine for their specific body workout, but it emphasizes adequate diet which is a balance between energy input from food consumption and energy output from exercise; it also focuses on the caring mental health from a doctor and health care providers, especially caregivers. A manual for specific physiotherapy programs was drawn up by developers to help patients exercise which involves a caregiver for primarily setting the instrument. The patients can use the machine to exercise their body, hands, legs or any limbs in various directions and subsequently improving the quality of the patient’s life—allowing for greater fitness levels and knowledge as shown in Fig. 15.

3. Results and Discussion

After the exercise machine MODEL-2 was completed, developers tested it on paralysed patients for a comparison of opinions against exercise machine MODEL-1.

Fig. 9 The base frame under the bed.
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Fig. 10  The sliding mechanism in whole body frame.

Fig. 11  The whole body frame that assembled parts for the exercise machine in bed.
The goal of the solution in the exercise machine MODEL-2; base of apparatus will not obstruct the wheel of the mobile table over the bed.

Fig. 13 The double rails under the bed were able to move along of bed length.

Fig. 14 The exercise set was move along the u-shape aluminium beam; its function was attaching the reel and the exercise gadget. The overlapped picture; showing the easy lock gadget for sliding on slot bar.
MODEL-1 was tested on a 22 years old male patient who has had a T-spine injury for 10 weeks, with the focus being on re-strengthening the patient for a month. MODEL-2 was tested on a 58 years old male patient who has had a C-spine injury for 10 years: the same exercise program was used for a month. To identify patient satisfaction, a testing scale was used with a range of 1 to 5 to help understand its effectiveness. The evaluation of holistic care is composed of physical, psychological, social, and spiritual parts which depend on disability and period of injury as Table 1.

Over recent years a portable in-bed exercising machine has provided the strengthening of muscles, a range of motion during exercise and a safe space, suitable for home parameters via set limit points [4]. Using In-Bed Exerciser decreases a physiotherapist workload because they can only visit a patient a few times a week. However, one particular drawback to the exercise machine is its features and functions are less convenient for all users. Alternatively, the exercise machine MODEL 2 can be applied to bed ridden patients with other conditions such as hemiplegic patients or quadriplegic patients. These patients might have the effect of locomotion disability rather than paraplegic patients. The results of both questionnaires indicate that the exercise equipment is a key factor in encouraging patients to keep fit at home. As a result of both exercise machine MODEL-1 and MODEL-2 help them feel happy, satisfied, safe, and convenient during exercise, because the exercise machines are good to order in design and suitable for their room. However, there are a few problems such as it is more complicated to assemble than machine for MODEL-1 and the effect of the severity of injury may even cause the limitation of their exercise, especially the lower part of body. As can be seen from the function of the exercise machines, they have an effect on physical, mental, and spiritual aspects; for example, they improve power of muscle function and range of joint motion, which allows the patient to feel good and relax, resulting in encouraging self-esteem. According to Table 1 in social part (question 6.3), the C-spine injury patient stated that he was a quadriplegic patient and that it was too difficult to go outside the home. This might not improve people interrelationships in the society. From this longsuffering result, there are developers who designed the robotic brain-controlled telepresence for motor disabled people via non-invasive electroencephalogram method. The inventors used the brain machine interface to control the robot in order to help disabled users move in non-familiar environments [5]. This continuation of innovations within this field displays the pursuit of a better life for people with physical disabilities.

3.1 Solution

One solution to deal with the health problems of
paraplegic patients is a well-developed exercise programme from the multidisciplinary team. As a result, developers are identifying typical problematic areas for individuals that can be addressed while they create the exercise machines. However, the previous researchers clarified the relationship between an individual and behavioral exercise as being influenced by thoughtful design of environments [6]. A healthy setting needs a multidisciplinary team: exercise scientists, health professionals, planners, designers, engineers, and psychologists. This collaboration is an important resource to facilitate physical activity and exercise behaviour in a diversity of the sedentary population. What this means is that designing the environment for supporting physical activity is similar to the process of building a specific exercise machine at home. Thus, designing a well-developed exercise programme for a paraplegic patient requires the particular collaboration of expertise, and more significantly, concerns regarding their circumstances. In addition to solving the problem, a well-developed exercise programme which integrates diet, mental health support, and exercise equipment can also provide many other benefits to bed ridden paraplegic

<table>
<thead>
<tr>
<th>Question</th>
<th>MODEL 1</th>
<th>Satisfy level</th>
<th>Reason</th>
<th>MODEL 2</th>
<th>Satisfy level</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Could you rate your satisfactory on the happiness on this exercise machine from scales 1 to 5?</td>
<td>3</td>
<td>-</td>
<td>It’s easy to use.</td>
<td>4</td>
<td>-</td>
<td>Aluminum frame look stable.</td>
</tr>
<tr>
<td>2. Could you rate your satisfactory on the strength on this exercise machine from scales 1 to 5?</td>
<td>5</td>
<td>Huge Aluminium frame.</td>
<td>I’m not sure about pulley lock but safety first check before use.</td>
<td>4</td>
<td>-</td>
<td>It’s easy to use.</td>
</tr>
<tr>
<td>3. Did you feel safe while this exercise machine was applied on you?</td>
<td>4</td>
<td>-</td>
<td>The exercise machine is in good order.</td>
<td>4</td>
<td>-</td>
<td>The exercise machine is suitable for my room.</td>
</tr>
<tr>
<td>4. Did you think this machine is convenient for applying on your bed?</td>
<td>4</td>
<td>It can adjustable in the proper position.</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>5. What do you think about the design of this exercise machine in terms of beauty and modernity?</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6. What do you think about this exercise machine in the following aspects?</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6.1 Physical part (ie; improved power of muscle function and full range of joint motion)</td>
<td>4</td>
<td>More complicated when to assemble the exercise machine.</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>6.2 Mental part (ie; feel good and relax when using the exercise machine)</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6.3 Social part (ie; improved people interrelationships)</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6.4 Spiritual part (ie; feel encouraged and improved self-esteem)</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7. Could you tell the limitations of this exercise machine?</td>
<td>3</td>
<td>-</td>
<td>My legs had less exercise.</td>
<td>3</td>
<td>-</td>
<td>I had a long time of severe injury.</td>
</tr>
<tr>
<td>8. How much do you ready of taking care yourself?</td>
<td>4</td>
<td>-</td>
<td>It helps me to exercise because easy to do when I want.</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>9. Do you think this exercise machine promotes you in desiring of exercise?</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10. What is/are the problem(s) of using this exercise machine?</td>
<td>Answer</td>
<td>Still have some difficulty and somewhat complicated to assemble the machine if exercise lower extremities.</td>
<td>Answer</td>
<td>None</td>
<td>I would like to see your team take the next step to develop one machine that can use for various parts of a body.</td>
<td></td>
</tr>
<tr>
<td>11. Are there any other comments?</td>
<td>None</td>
<td>-</td>
<td>-</td>
<td>None</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
patients.

3.2 Implication

Development of an exercise plan, which includes the use of an exercise machine targeted for special use with bed ridden paraplegic patients, controlled diet, and mental health support, can have numerous additional positive outcomes for patients. Exercise produces “happy hormones”: endorphins, serotonin, dopamine, and oxytocin. These hormones affect positive human emotions; for example, feeling strong, being lively, happy and essentially more self-confident. Sports oriented people are happier than non-active people [7]. Furthermore, happiness has a positive effect on health because it potentially protects against illness and is considered preventive medicine. What this means is that happy hormones can help to improve the immunity of people with physical disability. Subsequently, these patients can become more motivated because the “happy hormones” increase positive thoughts and feelings. Eventually, regular exercise may evolve into a daily routine as the attitude towards exercise gradually changes. However, there are a few limitations in the integrated solution presented which may prevent the successful implementation of it or the intended outcomes.

3.3 Evaluation

Although diet and mental support can be supported at home with few limitations, using a suitable exercise machine at home for paralysed patients requires a large financial investment, one that may or may not be covered by the patient’s insurance. For this reason, the majority of disabled people may lack sufficient personal funding to afford the assistive equipment, for example, an expensive machine such as a brain-controlled robotic exoskeleton. However, people with disabilities were interviewed their perspectives on rehabilitation. In brief, patients considered the opportunities of social connections, such as with a caregiver, more important than just equipment or machines [8]. What this mean is that the exercise machines at home are not a significant factor for rehabilitation or treatment with paraplegic patients because these machines reduce the interaction with a caregiver. Caregivers affect the emotional health of a patient rather than an exercise machine. Therefore, improving the quality of a patient’s life from an emotional viewpoint requires personal care versus the implementation of a home exercise machine. Adding this emotional element to the integrated plan, involving diet, exercise, and mental health support would be the most efficient way of improving their fitness levels and the quality of their lives, respectively.

4. Conclusion

Bed ridden paraplegic patients cannot access body training facilities, this leads to physical and mental health problems. As a result, a well-developed exercise programme from the multidisciplinary team can be seen as a solution. It is composed of an adequate diet, a body training programme, a caring mental health doctor and health care providers, especially caregivers, and the development of the exercise machine for a specific body workout. In particular, the design and development of new exercise machine has corrected a key drawback of the previous exercise machine which was based on bed ridden paraplegic patients’ activities. MODEL 2 has been invented with the concepts of full function, strength, safety and is compatible with space limitation. The exercise machine has the benefit to keep bed ridden paraplegic patients fit at home but depends on the severity and the duration of their injuries. However, there are additional positive outcomes, especially happy hormones but the exercise machine requires a large financial investment and reduces interaction with a caregiver. As a result, the strategy for caring for these patients needs holistic care; particularly the rise in the value of humanity and decrease disability discrimination.
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Reference


