Robotics as a Tool in Fundamental Nursing Education

Yasuko Kitajima[1], Mitsuhiro Nakamura[1], Jukai Maeda[1], Masako Kanai-Pak[1], Kyoko Aida[1], Zhifeng Huang[2], Ayanori Nagata[2], Taiki Ogata[2], Noriaki Kuwahara[3], and Jun Ota[2]

[1] Faculty of Nursing, Tokyo Ariake University of Medical and Health Sciences, 2-9-1 Ariake, Koto-ku, Tokyo 135-0063, Japan
{kitajima,m-nakamura,jukai,p-kanai,k-aida}@tau.ac.jp
[2] Research into Artifacts Center for Engineering (RACE), The University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa-shi, Chiba 277-8568, Japan
{zhifeng,nagata,ogata,ota}@race.u-tokyo.ac.jp
[3] Department of Advanced Fibro-Science, Kyoto Institute of Technology, Matsugasaki, Sakyo-ku, Kyoto 606-8585, Japan
nkuwahar@kit.ac.jp

Abstract. The main purpose of this study was to investigate whether the use of robotics can contribute to nursing education, using the training for wheelchair transfers. The most common and extensively used method for practical learning is role playing. However the nursing student cannot turn into a patient thoroughly. To solve this problem, we proposed the creation of a robot patient for wheelchair transfer techniques training.

The experiment was performed by a nurse. The nurse attempted to assist the robot patient by helping it to stand up from the wheelchair, utilizing the basic techniques and checklist found in the fundamental nursing education textbook. As a result of this study, we have determined that the utilization of a robot could contribute to the teaching material for nursing education, and created an opportunity to reconsider what is accepted as basics or fundamental techniques.

Keywords: Robot patient, Simulated patient, Nursing skill, Nursing Education, Checklist.

1 Introduction

With the arrival of the advanced medical care and the super-aging of society it is necessary in nursing education to train human resources who can flexibly handle the changes in the environment which surround society and public health care, and it is also becoming necessary to work toward the development of nursing as a specialist profession and train human resources who can meet the needs of people of all health levels.

Aware of the issue that "the improvement of nursing abilities of college program graduates is an problem which must be resolved in order for nursing schools to reliably meet the expectations of society and work for further development", MEXT (Ministry of Education, Culture, Sports, Science and Technology) compiled nursing ability goals

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to be reached at the time of a completion of college program in a 2004 report. One of these goals is "the ability to appropriately execute nursing care techniques" [1].

Practicing of techniques in fundamental nursing education is vital in order for individual students to learn the ability to appropriately execute nursing care techniques. This is because most of the actions performed in nursing techniques involve contact between the nurse and the patient, and nursing techniques which can be safely provided to the patient and which are of a certain standard are required, and they cannot be achieved simply by classroom learning.

Recently, simulators as teaching materials have been introduced which can more elaborately reproduce the conditions of patients such as audio-visual materials and dummies in order to teach nursing techniques. One of these which has been in use for a long time is the practice method wherein students play and experience the roles of both nurse and patient [2]. Of the techniques required in nursing education there are techniques such as simply making up a bed or drawing blood, where the condition of the patient does not largely effect the nursing techniques to be provided, as well as techniques such as wheelchair transfers where there are multiple methods of providing care depending on the condition of the patient or the environment.

In this research we focused on the wheelchair transfer technique, which differs greatly depending on the condition of the patient, to clarify whether robotics can be a useful learning tool in nursing education.

The patients who are the subject of wheelchair transfers in fundamental nursing education textbooks are not fixed because depending on the textbook there is a wide variety of settings and different methods of assistance are adopted based upon the condition of the patients. Also, many textbooks use healthy persons to play the part of the patient, and these patients possess an ADL (activities of daily living) level which allows the nurse who is providing the assistance to transfer them from the bed to the wheelchair alone [3]. When actually transferring a patient into a wheelchair in a hospital, etc., patients have a wide variety of physical conditions, and the textbooks only cover a small fraction of these. Considering these variations, it greatly exceeds the scope of patient settings in other nursing techniques such as drawing blood and bed bathing. The intent of the textbooks is to simply instruct regarding the basic wheelchair transfer technique, and upon learning the basic technique the nurse can apply the assistance method that fits the actual patient's condition. However, there remains the question of whether the ability to apply said assistance in such nursing techniques as wheelchair transfers where the patients' conditions vary widely will be acquired via these teaching methods. The basic technique of the method of wheelchair transfers has not yet been clarified in the first place. When humans take the natural action of moving from a sitting position to a standing position their trunks adopt a forward-bent posture, but in the textbooks for basic nursing techniques there is a tendency toward stating that the method of assisting a person such that their natural movement is not interfered with is the basic f technique or the wheelchair transfer assistance method [4].

Application ability is the concept of taking one thing and applying it to another thing to successfully apply it. As I previously stated, MEXT established "the ability to appropriately execute nursing techniques " [5] as a nursing abilities goal to be reached at the time of completion of a college program, but there is a limit to how much of all nursing techniques students can learn within class time, and students therefore need the ability to apply the nursing techniques which they have learned. I stated that the basic technique of the methods of wheelchair transfers which are the subject of this research has not been clarified, and if that is the case then it should be necessary to test a variety of methods. The learning method which will enable students to acquire application ability is surely one which reproduces as much as possible the condition of patients who cannot cooperate with the person playing the nurse, forcing the students to attempt wheelchair transfers through trial and error.

And this raises the issue of the simulated patient. In current nursing education, practice is generally carried out with the students themselves playing the nurses and patients. It is said that in such cases, the students playing the patients feel bad for the students playing the nurses, especially considering that they themselves are also studying nursing, so they cooperate so that the technique provision will be easier for the student playing the nurse [6]. Therefore, when practicing with other students there is definitely a limit to how well the part of an actual patient can be played. For example, in such cases where the student playing the nurse provided assistance wrongly and this would be likely to result in a fall, the student playing the patient would presumably sense the danger themselves and not entrust everything to the student playing the nurse and collapse.

In order to solve this problem, I attempted to use a robot as a simulated patient in this research. In recent years there are simulators on sale which can elaborately reproduce the ailments of patients. However these are simulators which focus on learning physical assessment and BLS (Basic Life Support), and the simulators themselves are not designed for the purpose of placement in sitting and standing positions. Furthermore, mannequins which simply have the form of a humans, while having movable joints, have no power in their bodies, so they are not suitable for a single caregiver to practice a wheelchair transfer. The robot used in this research replicates a patient who requires assistance in a wheelchair transfer. It can maintain a sitting position, but it cannot stand up under its own power, and it cannot stay standing without the support of a nurse. Furthermore, its standing position is also unstable and it falls easily.

In this research I investigate whether attempting wheelchair transfers with a robot as a simulated patient can be a useful learning tool in nursing education. At the same time, by using a robot which is not a human as a simulated patient, I reconsider the basic actions which have been adopted in traditional basic nursing education and investigate what the key for students to acquire "the ability to appropriately execute nursing care techniques" is.

2 Methods

2.1 Participants

The nurse with more than 10 years of clinical experience was the subjects.

2.2 Procedures

A robot placed into a sitting position in a wheelchair (hereinafter called the "robot patient") was used as a simulated patient. The nurse repeatedly performed the action of assisting the robot patient to stand it up, and then placing it back into a sitting position. The same action was also performed with a healthy person as the simulated patient.

The nurse attempted to stand up and then put back into a sitting position both the robot patient and the healthy person as a simulated patient, following assistance methods which were extracted from wheelchair transfer methods adopted by multiple basic nursing education textbooks (hereinafter called the "checklist") [7]. The checklist was created as an assistance method to transfer patients who are primarily in a sitting square position. There were 21 necessary assistance actions extracted (Table 1), and in basic nursing education this checklist is used to evaluate the state of students' wheelchair assistance technique learning. The target of this experiment was to analyze the actions of standing both a robot patient and a healthy person up from a sitting position in a wheelchair and then returning them to a seated position, so I decided to implement items 5 through 9-b and items 11-a through 11-b from the checklist.

Table 1. Evaluation items for transferring a patient from the bed to wheelchair

No.	Evaluation Items.
1-a	Set wheelchair at the side of the bed with 20 to 30-degree angle.
1-b	Place wheelchair close to the patient.
2	Brake the wheelchair.
3-a	Place nurse’s left feet forward and right leg backward when bringing the patient close to the edge of the bed.
3-b	Place nurse’s left leg between patient’s legs.
4-a	Support patient’s hip.
4-b	When bringing the patient close to the edge of the bed, move the patient’s center of the gravity to right and left.
5	Bring patient’s heels close to the bed.
6	Place patient’s both arms around nurse’s shoulder.
7	Position of trainee’s hands in patient’ back.
8-a	Place nurse’s left feet forward and right leg backward when patient stands up.
8-b	Place nurse’s foot between patient’s legs.
9-a	Lowest height of the trainee’s waist.
9-b	Bending angle of patients’ back before hip away from the bed.
10	Turn patient toward the wheelchair.
11-a	Nurse bends the knees while placing the patient in the wheelchair.
11-b	Angle of patients’ back before sit down.
12	Hold patient’s forearm from behind the patient and the patient’s both the side.
13	Bring the patient’s buttocks towards the back of the wheelchair while placing patient’s head lower.
14-a	Bring down footrest of the wheelchair.
14-b	Place patient’s feet on the footrest.

First of all, the nurse said "Hello" to the robot patient. The robot patient replied "Hello". Next, the nurse was instructed to place and hold both of the robot patient's arms on the nurse's shoulders. After placing the robot's arms on her shoulders, the nurse assisted the robot patient so that it could stand from the wheelchair. After standing the robot patient, the knee joints locked and it was confirmed that it could maintain a standing position with support. Next, the nurse told the robot patient to "please sit", and the robot patient replied "okay" before beginning the sitting action. The nurse unlocked the robot patient's knee joints and assisted it in taking a sitting position as if collapsing to sit it in the wheelchair.

Additionally, the nurse performed the same actions upon a simulated patient played by a healthy person. This simulated patient had 30 hours of experience performing the wheelchair transfer actions as a simulated patient. Furthermore, this simulated patient was 160cm tall, which was almost the same as the robot patient.

In order to analyze the actions with both the robot patient and the healthy person, a camera was used to record the image sequence of experiment. The trajectories of the head of each of the patients when in a sitting position and standing position were extracted and compared.

2.3 Robot Patient

The robot patient was 160cm tall and weighed 25kg. This could be called lighter than the average patient, but this weight was chosen in this research to ensure the safety of the students (Fig.1).

The upper limbs of the robot patient have 3 joints including 2 shoulder joints and elbow joints. The upper limbs can be held on the participant's shoulders and can remain held there. The robot patient cannot hold onto the participant's shoulders by itself, so the participant helps the robot patient to perform the holding action. When the height of the arms is lower than the position of the shoulders, the shoulder joints are not locked. And when the arms are in a higher position than the shoulders, the shoulder joints and elbow joints are locked and the embracing posture is maintained. The posture of this robot patient continues to be maintained during the process of standing from the wheelchair and sitting.

An electric brake is installed in the robot patient's knee joints so that it can maintain a standing position. An angle sensor is also installed to detect the angle of the knee joints. The minimum angle for the knee joints to maintain a standing position is 165 degrees. During the process of the robot patient standing from the wheelchair, the electric brake of the knee joints is turned off so that it moves with the assistance of the participant and can open freely. This is so that the position of the legs can be freely adjusted in the preparations for the participant to stand the robot patient, and also so that assistance in taking a standing position can be given. The electric brake is set to work when the left or right knee joint opens wider than 165 degrees. Furthermore, the torque of the knee joints is set to instantly switch to zero when the electric brake turns off. The reaction time for this to happen is less than 1 second. This reaction speed recreates the way an actual patient's knee joints suddenly buckle when they start to move from a standing to a sitting position [8].

The voice interaction was realized by the voice recognition module. The robot patient is created to recognize the two Japanese phrases "hello" and "please sit". When the participant says "Hello" to the robot patient, the robot patient replies "Hello". And when told "please sit", it replies "okay". The robot patient says "okay" only after it has taken a standing position, and after replying the robot patient releases its knee joints in order to take a sitting position. The torque of friction of the brake would support the robot patient’s weight to keep standing. The robot patient maintains a standing position until the participant gives the instruction to "please sit". After recognizing the phrase "please sit" by the participant, the robot patient releases its knee joints and begins to take a sitting position.

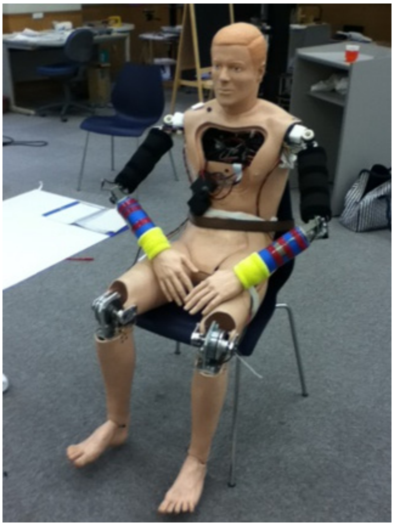

Fig. 1. Robot patient for wheelchair transfer practice

3 Results and Consideration

The nurse who actually participated in the first experiment performed the assistance according to the checklist to assist the robot patient to stand, but was not able to make it stand at all. We will now consider the reasons she was unable to do so. First of all, in checklist 7, "Position of trainee’s hands in patient’ back", it was predicted from before the trial that the nurse was unable to effectively utilize her power and would have difficulty standing the robot patient. Instead of the robot patient’s back, she put her hands under the it’s armpits [9] (Fig. 2).

Fig. 2. Comparison of robot and human, position of the nurse’s hands

Next, she tried checklist 9-b, "Bending angle of patients’ back before hip away from the bed.", but the robot patient's back did not bend and its upper body simply slid down from the wheelchair toward the nurse, and assisting the robot patient to take natural actions to stand like a human was ineffective (Fig. 3). Furthermore, the nurse who participated in the experiment had experience in standing up the healthy human acting as a simulated patient according to the checklist, so she was left with the sense that if she assisted the simulated patient as per the checklist the simulated patient would cooperate in standing. Therefore the nurse didn’t exert force from the start upon the robot patient which couldn't move at all under its own power and did not enter the action of making the patient stand, which was presumably the reason she was unable to put it in a standing position. Furthermore, when the standing robot suddenly released its knee joints like an actual patient, there was no chance to attempt checklist 11-a, "Nurse bends the knees while placing the patient in the wheelchair", and 11-b, "Angle of patients’ back before sit down.", and there was a risk of letting the robot fall.

The nurse who participated in the experiment was very experienced, so after several attempts she became able to perform the wheelchair transfer upon the robot patient, but the method she used diverged greatly from the checklist (Fig. 4). Looking at Fig. 5, there is a difference between the trajectories of the head when taking a seat from a standing position with both the robot patient and the healthy person as simulated patients. Furthermore, it is clearly shown that there is significant difference in the trajectories of the head when standing from a seated position. In the case of the healthy person as the simulated patient, assisting as if simply performing the natural actions of helping a person to stand from a seated position will achieve a standing position. In the case of the robot patient, unlike the human, the head's trajectories proceeds in an almost strait light toward the return point.

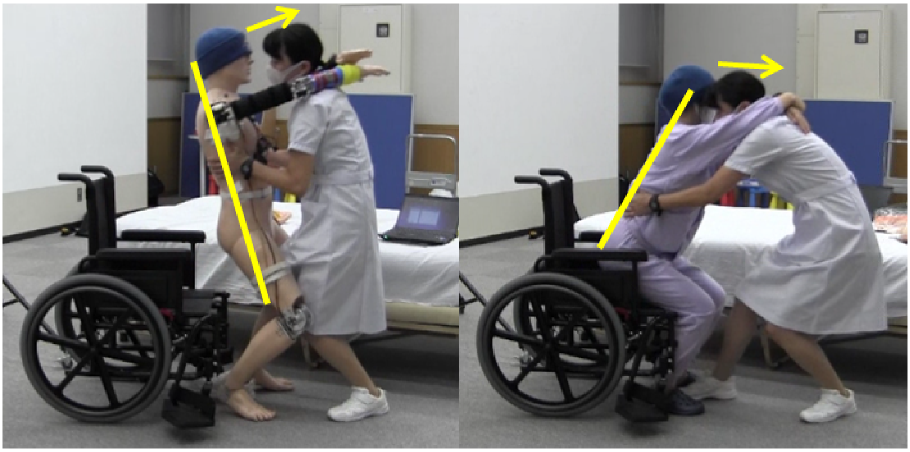

Fig. 3. Comparison of robot and human, bending angle of back

In basic nursing education for assisting patients with physical motions, students are taught to assist in keeping with movements which are naturally inherent to humans [10], and in the checklist to evaluate whether they have acquired said techniques or not as well it is established that actions which are more like helping with a human's natural motions are important actions. However, there are many patients like the robot patient used in this experiment who have some problem which prevents them from performing natural human movements. On the contrary, it could be said that in clinical settings such patients are the majority. In this experiment, we have succeeded in assisting a robot patient in moving from a sitting position to a standing one, as well as from a standing position to a sitting one, without using the assistance methods taught in basic nursing education. The key to the success was the repetition of assistance methods again and again through trial and error until the goal of standing the patient up was achieved. The assistance actions used to achieve the goal were different from those in the checklist, but it led to the result of her mastering the wheelchair transfer assistance method which she thought up by using her own body. If this were a nursing student, it would seem that rather than mimicking the so-called basic movements which are unilaterally taught in basic nursing education, a student using his or her body and head in given circumstances to acquire the technique needed to achieve a goal will come closer to the acquisition of "the ability to appropriately execute nursing care techniques" proposed by MEXT. This was an opportunity to reconsider the idea that has been believed in traditional basic nursing education, namely that application ability follows basic techniques.

Fig. 4. A sequence of actions of wheelchair transfer methods (Left robot and human right)

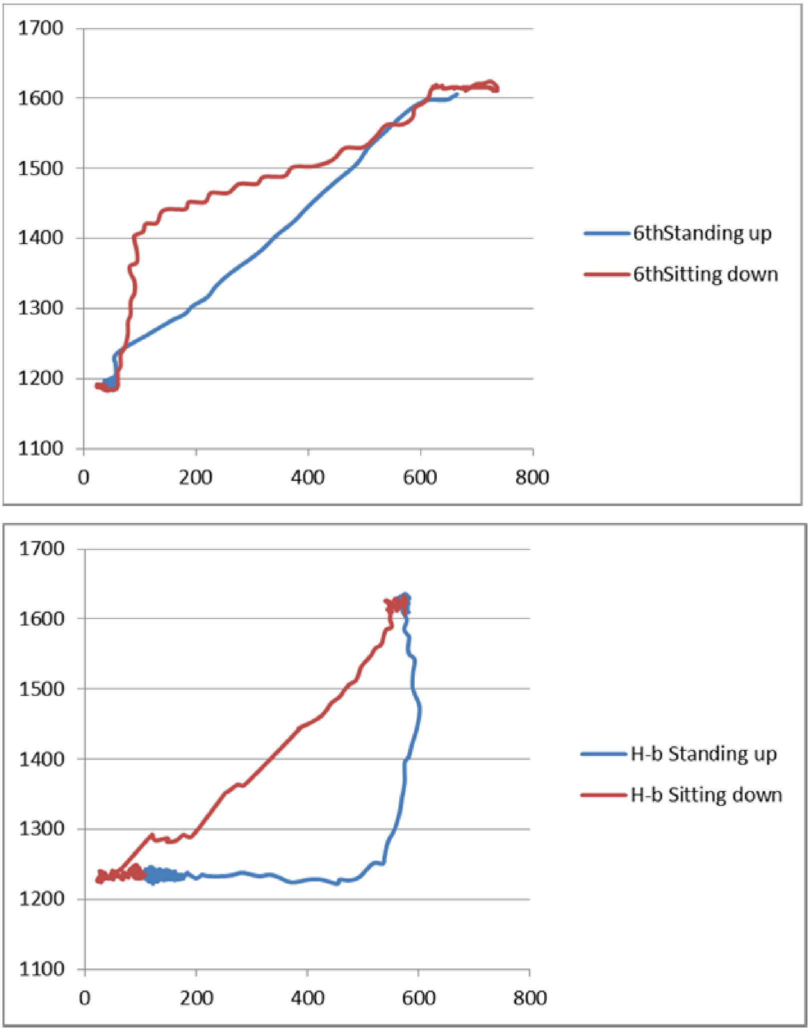

Fig. 5. Comparison of robot and human**,** the trajectories of the head (Above the robot and under human)

4 Conclusion

Based upon the above, in nursing techniques where the physical condition of the patient has a large influence upon the method of the techniques to be provided, the basic techniques themselves are vague [11], so if students are to acquire application abilities, they must think up and attempt multiple methods repeatedly by themselves upon a simulated patient. For this purpose it is important for the simulated patient to be able to thoroughly reproduce a patient. At the same time, it is also important for there to be no danger of fatigue or injury to the simulated patient during practice. Robot patients can be said to fulfill these requirements. Considering this, we propose that robot patients can be useful learning tools in nursing education.

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