Indirect Evaluation of Nurse's Transfer Skill Through the Measurement of Patient

Chingszu Lin[1(✉)], Zhifeng Huang[2], Masako Kanai-Pak[3], Jukai Maeda[4], Yasuko Kitajima[4], Mitsuhiro Nakamura[4], Noriaki Kuwahara[5], Taiki Ogata[1], and Jun Ota[1]

[1] Research into Artifacts, Center for Engineering of the University of Tokyo, Chiba 277-8568, Japan
lin@race.u-tokyo.ac.jp
[2] Department of Automation of Guangdong University of Technology, Guangdong 510006, China
[3] Faculty of Nursing of Kanto Gakuin University, Yokohama 236-8501, Japan
[4] Faculty of Nursing of Tokyo Ariake University of Medical and Health Sciences, Tokyo 135-0063, Japan
[5] Department of Advanced Fibro-Science, Kyoto Institute of Technology, Kyoto 606-8585, Japan

Abstract. Nowadays with the advancement of technology, many evaluation systems have been developed for skill learning. However, those systems are inevitable to set the sensors on trainees or environment (e.g. camera). Therefore this study aims to propose a method to indirectly evaluate the patient transfer skill through only measuring the patient, instead of the nurse. Based on the observation of the patient's movements during transfer, joint angle and acceleration of patient are determined as two parameters to evaluate the nurse's skill. Incorrect ways of transfer skill were added into a checklist, proposed in our pre-work, based on clinical experience of nursing teachers. An experiment was conducted by two nursing teachers, and they were asked to carry out the patient transfer skill through both correct and incorrect ways as proposed in the checklist. The results exhibit those two parameters enable to show the difference while the nurses carried out the incorrect way. The angles of hip and knee joints enable to reveal the difference in the steps related to standing up and sitting down; while the acceleration of patient can exhibit the difference of patient's dynamic movement. According to such results, the indirect evaluation became practical for the future works.

Keywords: Patient transfer skill · Motion measurement · Indirect evaluation

1 Introduction

According to American Association of Colleges of Nursing's report [1], an issues of faculty shortage is raised, which contributes to the ratio of students and teachers in clinical courses becomes smaller. However, many currents researches state the smaller class sizes tends to be associated with higher quality [2, 3]. In this way the students

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enable undergoing the supervision and evaluation of teachers and obtain the guidance and feedback of their performance. Such evaluation and feedback in clinic education have been considered an essential step in the acquisition of clinical skills [4]. Therefore, according to the background of faculty shortage, proposing the evaluation system for nursing students without the teacher's supervision becomes urgent.

Accompanying with the technological progress, many researches dedicate a great effort on developing the evaluation and motion measurement of skills in a diversity of fields. Particular in sports, the measurement of the trainees through sensors are widely utilized to enhance the motor skill learning. For example, a single 2D stationary camera was employed to analyze the user's motion in Taichi and golf swing [5]. Other research employed the 3D motion to extract the difference between expert and novice of goal player [6]. Another system used the MEMS inertial sensors attached on the goal club to evaluate the golf swing [7]. In addition, a system was proposed by using the underwater camera, wearable LED marker, and pressure sensor to analyze the skill of swimmer [8]. Furthermore, *Gray et al.* employed magnetic-field search-coil technique to measure the position, velocity, and acceleration of the arm between expert and unskilled pitcher [9]. Except from the sports, a learning system of dancing with immediate feedback by employing the 3D motion capture technology was proposed in [10]. Also a study investigated the difference of expert and novice piano player in the of upper-limb movement through both EMG and camera [11]. For the fields related to the nursing education, a research developed an evaluation system for self-training of bed-making activity [12]. And our pre-work proposed a self-help training system for learning the patient transfer skills by using the same Kinect sensor [13]. However, those previous studies had not measured what will occur if the incorrect skill was applied by trainees. Particularly in the field of nursing, it is important to realize what kind of influence will bring to the patient if the nurses employ incorrect ways. Furthermore, despite that those previous studies had proposed different methods to evaluate the learner's performance, the installations of sensor on the learner and environment are inevitable, such as markers on learner' body or the cameras around the learner.

To propose an evaluation system, we assume the nurse's correct and incorrect ways will contribute the different influence on the patients, because the transfer skill has a cooperative and mutual relation between nurse's skill and patient's movement. Accordingly, this study aims to verify if only the measurement of patent enables to exhibit the difference while the nurses carry out the correct and incorrect ways of patient transfer skill. The first challenging point is there are various parameters to measure the influence of patient (e.g. position, velocity, acceleration). Therefore, how to determine the enough parameters to observe the influence caused by the nurses is difficult. The approach is first to observe the movements of patient during the transfer, and then the joint angle and acceleration were selected as optimal parameters to exhibit the difference between the correct and incorrect ways. The other challenging point is during the whole process of transfer skill, different steps have the influence. In short, the some previous steps causes the influence on the following steps. Therefore a checklist based on the clinic experience of nursing teacher was proposed. In the checklist the following step that may causes the influence on the patient is also listed down; and measurement of the patient should also cover those following steps.

2 Proposed Method

2.1 Process of Patient Transfer Skill

With the aging society, patient transfer become more indispensable to take care of senior patients and other physical injured patient frequently in hospitals or homes [14]. Patient transfer skill can be executed in many different scenarios. Transfer skill allows the patients to be able to move from the wards to other places and conduct the daily routine, such as going to toilet or bathroom. However, this skill is one of the most complicated and difficult tasks, because it requires entire body mechanics (e.g., position, posture, method of movement), and also the knowledge related to wheelchair. Furthermore, the appropriated mutual interaction and cooperation between patient and nurses are required to ensure patient comfort and prevent incident. To move the patient from There are 6 main steps during patient transfer as shown in Fig. 1. The steps are placing the wheelchair, mutual hugging, standing up, pivot turning, sitting down on the wheelchair, and final posture adjustment.

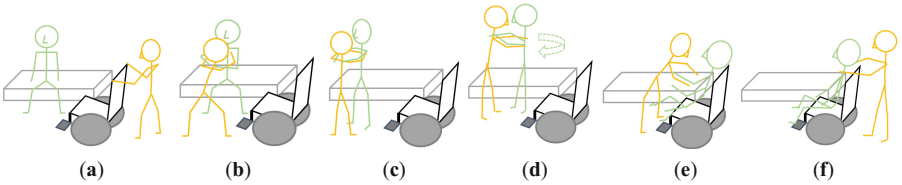

Fig. 1. Patient transfer skill of (a) placing the wheelchair, (b) mutual hugging, (c) standing up, (d) pivot turning, (e) sitting down on the wheelchair, and (f) final posture adjustment

2.2 Checklist

To observe the influence of patient while the nursing skills were carried out, the checklist were proposed by the nursing teachers with more than 10 year clinical experience. The checklist were comprised by the step No. 1 to 16 with the correct way which represent the appropriate way which extracted from the nursing material. Because there are many different incorrect ways which differs from nurses to nurses, we selected the incorrect ways as the most common mistake to nursing student base on the experience of nursing teachers. In this way the influence on the patient become more meaningful to represents the conventional situation when the incorrect were applied. In addition, the step, which may occur the difference influence on the patient while the correct and incorrect way were applied, were also listed down in the last column of the checklist. Some difference influence of the patient occurs on the present step when the incorrect skill were applied, while some occurs in following steps. Such scenario that the previous steps affect the following steps is because transfer skill has strong connection between different steps. For example, the placement of wheelchair of No. 1 and No. 3 will have the influence on patient during the pivot turning step of No. 12. The checklist contains 16 evaluation items, and 12 items were written with the common mistakes. Each referring to clinical experience and nursing material (Table 1).

Table 1. Checklist of patient transfer with correct and incorrect ways

Step No.	Correct way	Incorrect way	Step occurs different influence
1	Place the wheelchair at the bedside and adjust the angle to 20–30°	Place the wheelchair at the bedside with too large angle	No. 12
2	Place the wheelchair near the patient	Place the wheelchair too far from the bed	No. 12
3	Apply the wheelchair brakes	Did not apply the brake	No. 15
4	Place one of your feet behind you, and another foot between the feet of the patient	–	–
5	Enable the patient to sit on the edge of the bed by rocking the patient's bottom.	Did not move the patient to the edge of the bed	No. 10
6	Adjust the patient's leg posture and move ankle closed to the bed	Move the patient ankle far from the bed	No. 6 No. 11
7	Place both arms of the patient on your shoulders and hugging mutually	Did not (hug with the patient) place both arms of the patient on your shoulders	No. 7 No. 12
8	Clutch the lower back of the patient.	–	–
9	Place your right foot behind you and left foot between the feet of the patient	Place the woring position that left foot behind and right foot between the feet of the patient	No. 12
10	Squat down and lower your waist in order to prepare the patient to stand up	Did not bend your knees and lower the waist	No. 11
11	Make the patient lean down, and then assist the patient to stand up	Did not make the patient lean down first, stand up the patient vertically	No. 11
12	Use your left foot as a pivot axis to help the patient turn to the wheelchair	–	–
13	Place one of your feet behind you, and another foot between the feet of the patient	–	–
14	Lower your waist in order to prepare to assist the patient to sit down	Did not lower waist and bend the knee to assist the patient to sit down	No. 15
15	Make the patient lean down and assist the patient to sit down	Did not make the patient lead down first, before making them sit down	No. 15
16	Make the patient sit in the wheelchair through pulling with both arms	Lift the patient up vertically and move the patient sit at inner side of wheelchair	No. 16

2.3 Determination of Parameter

In this section, we determined two parameters to observe the patient, which are joint angle and acceleration. Those two parameters were selected because, firstly human posture refers to the physical configurations that comprised of the different angles of joint; and secondly, acceleration in physics enables to exhibits the dynamic movement of patient caused by the forces of the nurses.

3 Experiment

3.1 Purpose

In order to evaluate the nurse's skill through the measurement of patient, the following crucial points should be realized in this experiment.

- To approve the nurse's correct and incorrect skill cause the different influence of the joint angle and acceleration on patient.
- To observe where are the location on patient to measure the difference influence between correct and incorrect ways executed by the nurses,

3.2 Participant

The experiment invited two experienced nursing teachers as the participants. Both nursing teachers have the clinical experience in patient transfer. The nursing teaches were asked to be a skill performer and also a simulated patient during the experiment. In addition, the procedures were approved by the Ethics Committee at the University of Tokyo, and both participants provided their written informed consent prior to enrollment.

3.3 Experiment Procedure

The first step is to ask the nursing teachers conducting the correct way of patient transfer from step No. 1 to 16 for one trail. The second step is ask the nursing teacher to execute the step with the incorrect way for also one trial. An experimental picture is shown in Fig. 2.

In each step, firstly one nursing teacher carry out the transfer skill, and the other nursing teacher simulates the patient. After that they switched the role and carried the transfer skill again. The simulated patient by the nurses is determined as the patient affected by week lower limbs that required assists during transferring. And this is the reason that participant reproducing the patient should be the nursing teachers who have the clinic experience to imitate such patient.

Fig. 2. Patient transfer trial conducted by nursing teachers

3.4 Experiment Setting

The basic elements of patient transfer include a bed and a wheelchair. The height of the bed was adjusted at 50 cm, and the wheelchair was placed beside the bed. In addition, 12 motion capture cameras were set around the bed to measure the joint angle. Also motion capture markers are attached on the patient. Additionally, the inertial sensors were attached on the patient's arms, thighs, chest and waist to measure the acceleration. Even though the motion capture system enable to measure the both joint angle and acceleration, but in the future we aims only use angular sensor and inertial sensors to avoid complication setting. Thus in this study, the acceleration was measured by inertial sensors to verify the feasibility our proposed method. The sensor and marker setting had described previous as shown in the Fig. 3. All the x axis of inertial sensors is facing down. And the z axis of sensor on the chest, waist and thigh is facing backward during standing pose; while the y axis of both arm is facing front side. Last, two web cameras were utilized to record the experiment.

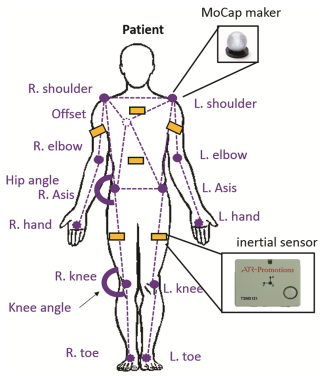

Fig. 3. Setting of motion capture marker and inertial sensor on the patient

3.5 Result

The results of all the steps in checklist are a large among of information; therefore, this paper only presents partial results.

- Posture of patient's joint

For the step No. 5, 6, and 11, the difference influence on the patient between correct and incorrect ways occurred at the step No. 11, which is to assist the patient standing up. First of all, the flexion angle of knee and hip through the correct way are presented in Fig. 4, and those Figures will be compared with other results through the incorrect ways.

For the step No. 5, the correct way is to move the patient to the edge of the bed; while the incorrect way is not carrying out this step, making the patient did not move to the edge of bed. The difference influence on patient between correct and incorrect ways occurs on the hip joint during the standing up step No. 11. If the incorrect way was executed, then the flexion angle of hip joint increased from 60 to 80° for trial of Teacher

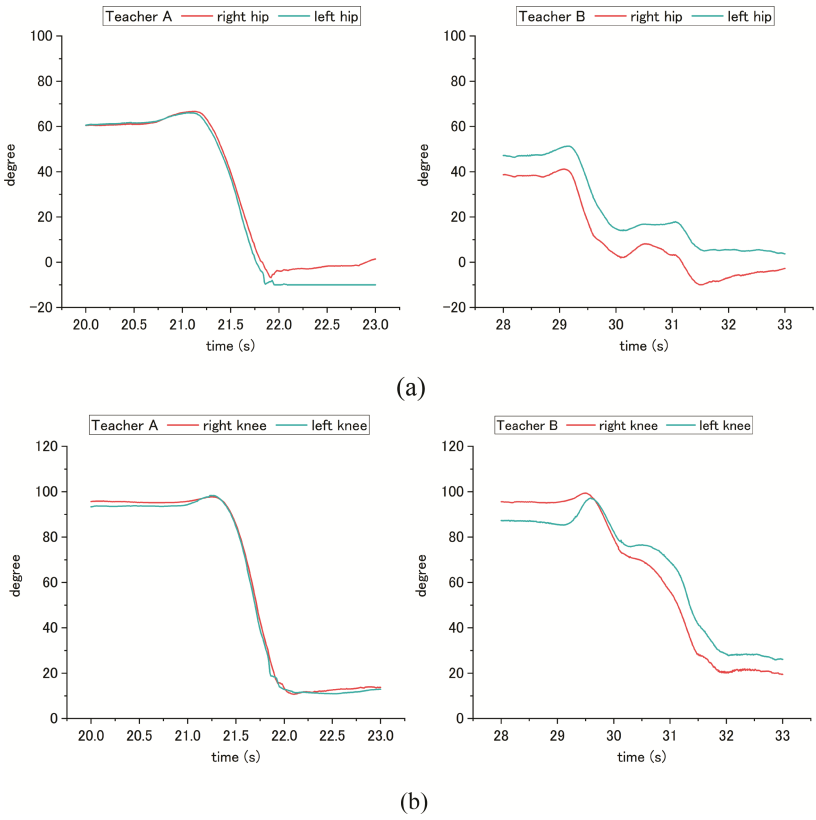

Fig. 4. Flexion angle of patient's (a) hip and (b) knee during step No. 11 (standing up) when correct way was conducted

A; while the angle increase from about 50 to 60° for the trial of Teacher B, as shown in Fig. 5.

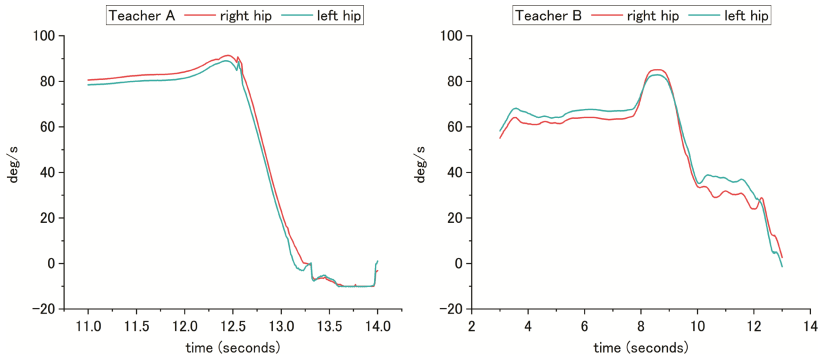

Fig. 5. Flexion angle of patient's hip during step No. 11 (standing up) when incorrect way was conducted at step No. 5

The step No. 6 is to move the patient's ankle closed to the bed; and the incorrect way is moving the patient's ankle too far from the bed. Those ways lead to the difference on the present step No. 6 and also the standing up step No. 11. As shown in the Fig. 6, when putting the heel too far away from the bed, the flexion angle of keen of the patient become smaller at the beginning, compared with Fig. 4(b). Also during the standing up at step No. 11, the hip joint will increase and form a peak cure which cannot be seen in the correct way.

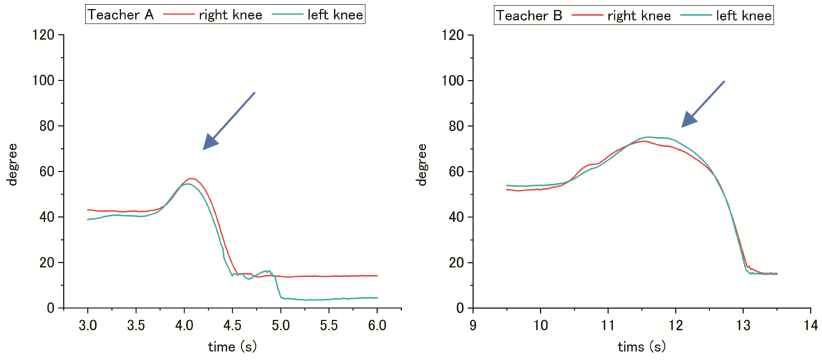

Fig. 6. Flexion angle of patient's knee during the step No. 6 and 11 when incorrect way was conducted at step No. 6

In term of the step No. 15, the appropriate way is making the patient lean down first before assisting them to sit down; while the common mistake is making the patient to sit down on the wheelchair by moving the patient's trunk vertically downward from standing condition to sitting. In Figs. 7 and 8, the result shows through the correct way the hip joint kept increasing until the patient sitting on the seat surface, and then angle

started to decrease until reaching he angle which smaller than 40°. However, the results through the incorrect way did not have such obvious decreasing after the patient sit on the wheelchair.

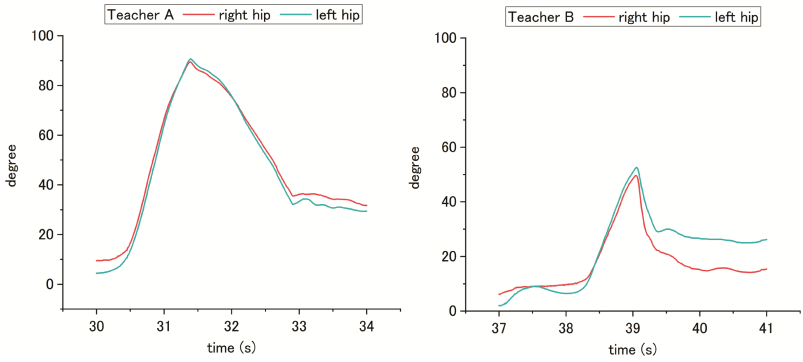

Fig. 7. Flexion angle of patient's hip during step No. 15 (sitting down) when correct way was conducted at step No. 15

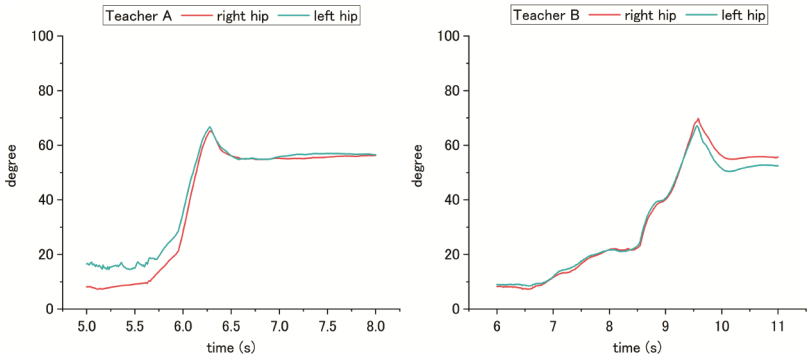

Fig. 8. Flexion angle of patient's hip during step No. 15 (sitting down) when incorrect way was conducted at step No. 15

For the last step No. 16 adjusting the final posture to make the patient sitting against to the backrest of wheelchair, the correct way is to hold the patient' both arm and make then leaning down before pulling them to the backrest. And the support the patient trunk making them to lean against on the backrest. In contrast, the incorrect way is holding the patient's armpits and lift them up, and then move them closed to the backrest. Finally release the armpits and make the patient sit on the wheelchair. The results show the flexion angle of hip joint first increased and then decreased when the correct was applied; while through the result is contrary, then angle decreased first and then increased, as shown in Figs. 9 and 10.

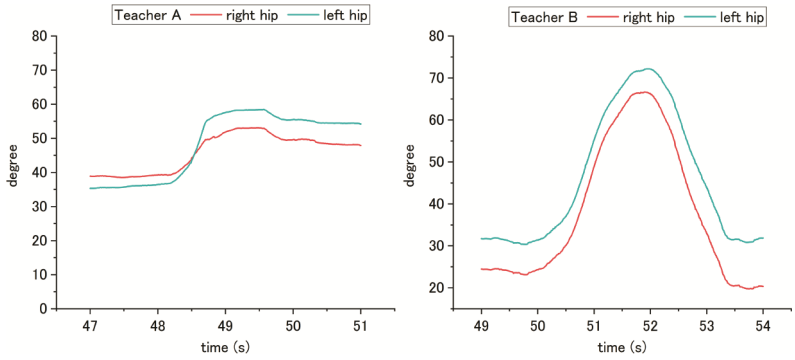

Fig. 9. Flexion angle of patient's hip during step No. 16 when correct way was conducted at step No. 16.

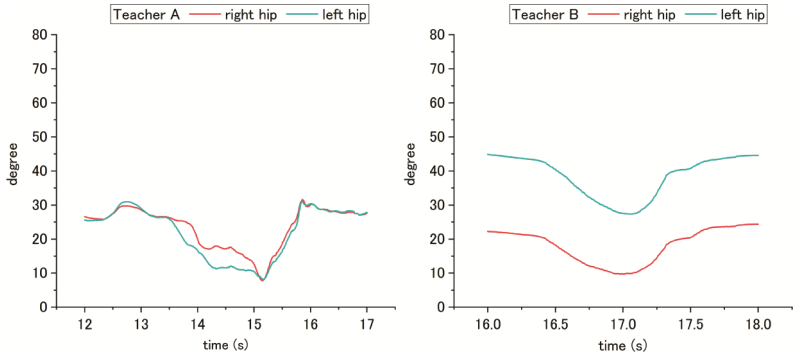

Fig. 10. Flexion angle of patient's hip during step No. 16 when incorrect way conducted at step No. 16.

- Acceleration of patient's motion

For the step No. 10, the appropriated way of nurses is to squat down and lower their waist before assisting the patient to stand up. The incorrect way is standing straightly without lower their waist when supporting the patient to stand up. The difference influence on patient happens during the standing up at step No. 11. When the nurses did not lower the waist and then holding the patient to stand up, the acceleration increase from −600 to −1000 mG during the process while standing up in the trial of teacher A. However, for the trial of teacher B, such difference in acceleration is not significant, as shown in Figs. 11 and 12. The explanation is presented in the discussion.

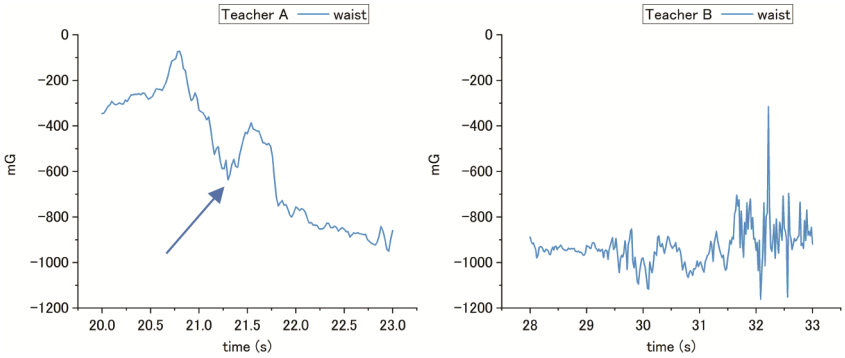

Fig. 11. Acceleration of patient's waist during step No. 11 (standing up) through correct way conducted at step No. 10.

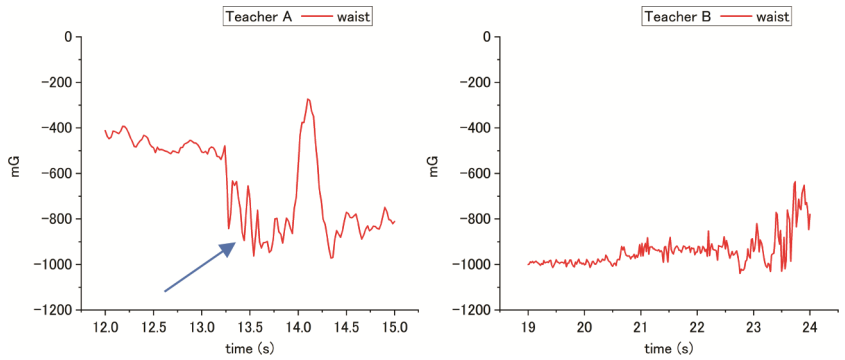

Fig. 12. Acceleration of patient's waist during step No. 15 (sitting down) through incorrect way conducted at step No. 10.

The step No. 14 is asking the nurses to lower their waist before making patient to sit down. And the incorrect way is not lower their waist. The different influence is the acceleration of the patient's waist during the sting down No. 15. The correct way has the smaller acceleration downward; while the acceleration downward became larger when the nurses do not lower their waist as shown in Figs. 13 and 14.

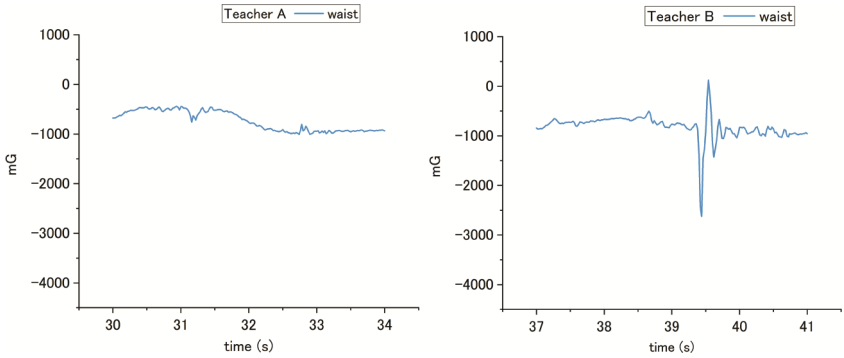

Fig. 13. Acceleration of patient's waist during step No. 15 (sitting down) through correct way conducted at step No. 14

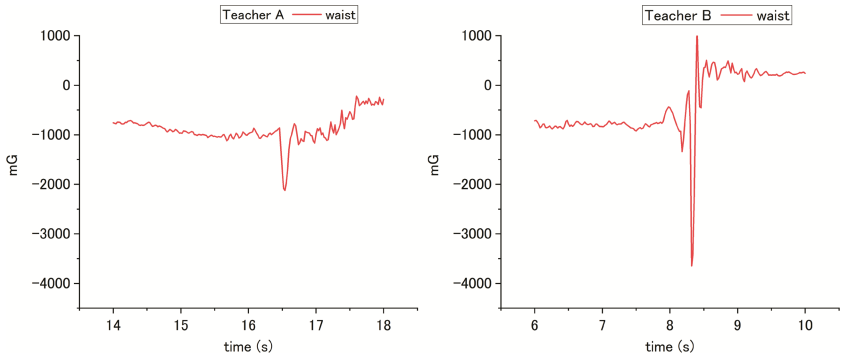

Fig. 14. Acceleration of patient's waist during step No. 15 (sitting down) through incorrect way conducted at step No. 14

3.6 Discussion

According to the results, the joint angle enables to evaluate many steps in the checklist. This reveals the joint angle is one of the crucial parameter to evaluate the nursing skill during the transfer. Those angle joints of hip and knee which are highly effected by the performance of nurse. The angle of hip and knee are capable to reflect the different influence of lower limbs when standing up, sitting down, and the movement involved leaning down.

In addition, the acceleration of waist enables to distinguish the correct and incorrect ways of nurse. Also the acceleration associates with the feeling of patient; therefore it can be a critical parameter to evaluate the skill performance of the nurses. However, in this experience, the different height of patients which simulated by different nursing teachers brings about the limitation. For example the step No. 10, as shown in Figs. 11 and 12, because Teacher B is shorter than the patient simulate by the Teacher A, making the Teacher B difficult to quickly lift up the patient when lower limbs are straight without

bending. Therefore, the quality of acceleration did not become larger when Teacher B did not lower the waist on the step 10. Such condition reveals that the different height of patient also influence the skill perforce of nurses, and this issue should be solved for in the future works, such as using the same simulated patient.

4 Conclusions and Future Works

With the goal to evaluate the nurse's skill through only the measurement of patient, this study verified if the joint angle and acceleration of patient enable to show the difference while the correct and incorrect ways were applied by the nurses. The checklist comprised by 16 steps were proposed by the nursing teacher with correct and incorrect way. The incorrect was is determined by the most common mistake of nursing student. An experiment was conducted by the two nursing teachers. They are asked to carry out both correct and incorrect ways. According to the result, the joint angle exhibits the difference between correct and incorrect ways on more than five steps, revealing the joint angle is an essential parameter to evaluate the nursing skill. Especially the hip and knee joint can informatively exhibit the standing up and sitting down movement of patient with details. The acceleration of waist enables to show the difference of two steps, and the quantitative value reveals the dynamic condition of patient.

For the future works, more parameters will be found to observe the steps that are unable to exhibit the difference through the joint angle and acceleration. In addition more participants will be invited to conduct the transfer skill, so that the threshold for evaluation can be determined. Furthermore the angular sensor will be developed to attach on the patient, in order to replace the motion capture system which requires the complicated setting on both patient and camera.

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