Nursing Students' Motion Posture Evaluation Using Human Pose Estimation

Makoto Nishimura[1], Makiko Itoi[1], Masaki Saito[2], Kensuke Tsurumaki[2], Miki Kurushima[3], and Kiyoko Tokunaga[1]
[1] Kyoto Koka Women's University, Kyoto, Japan
[2] Fujitsu Advanced Engineering Limited, Tokyo, Japan
[3] Kyoto Nursing University, Kyoto, Japan
Email: m-yamashita@mail.koka.ac.jp, m-yamashita@mail.koka.ac.jp

***Abstract*—Appropriate motion posture based on biomechanics is important to prevent lower back pain in nurses and nursing aides. We applied our human pose estimation system to evaluate nursing students' motion posture fairly and effectively. This study examined 31 nursing students who had already learned about using biomechanics. These participants showed part of a fundamental nursing skill of "bedmaking." Then researchers recorded the motion. Videos were analyzed using the human pose estimation system developed by Fujitsu Advanced Engineering Ltd. The center of gravity (COG) height was calculated for motion posture evaluation. To compare COGs of participants evaluated as passing (Good group) by teachers with those of failing participants (Bad group), t-tests and ANOVA were used. We analyzed 16 participants excluding 15 participants because of their video's defect. Heights of all participants were 159.3±6.3 cm. The COG was 94.0±6.7 cm. Good group (*n* = 7) nurses showed significantly lower COG during motion than the Bad group (*n* = 9) did (Good group, 66.5±7.0 cm; Bad group, 74.8±6.4 cm, *p* < 0.001). Some participants with inadequate COG lowering were included in the Good group. The COG during motion was calculated accurately using the human pose estimation system. Results demonstrated a definite difference of COG between Good and Bad groups, and demonstrated teacher evaluation as ambiguous. The system might support teachers, enabling higher accuracy evaluation of students' motion posture.**

***Index Terms*—Human pose estimation system, motion posture, nursing student**

I. Introduction

Nurses and nursing aides are affected by musculoskeletal disorders, especially lower back pain. Davis et al. after a comprehensive review, reported the mean prevalence for lower back pain among nurses in hospitals, long-term care facilities, and home health care was 65% over their lifetime, 55% for the prior year, and 35% for current symptoms [1]. Because work-related lower back pain becomes chronic in many cases, it is important that it be prevented. Some researchers have reported studies conducted to design and evaluate lower back pain prevention programs [2], [3].

In Japan, to prevent lower back pain, nursing students learn about using biomechanics and how to use equipment based on a no lift policy. In many nursing training faculties including those at universities, teachers use practical examinations to evaluate whether students acquire the use of biomechanics. However, some difficulties exist in relation to their evaluations. First, no definitive standard of using biomechanics exists. Therefore, evaluation by multiple teachers lacks consistency. Second, teachers require long periods of time for evaluation because one hundred or more nursing students per academic year must be evaluated in typical Japanese programs. Third, students can not receive immediate feedback.

We introduced the human pose estimation system to resolve the related difficulties. This system enables visualization and digitalization of the motion posture. This study was designed to clarify differences between evaluation conducted by the system and by a teacher, and to assess whether the system can evaluate a nursing student's motion posture from the viewpoint of using biomechanics.

II. Methods

A. Nursing Skill Targeted for This Study

Bedmaking was targeted for this study. Bedmaking is the first skill that nursing students learn at almost all nursing training facilities including universities. Nursing students can acquire the use of biomechanics through bedmaking.

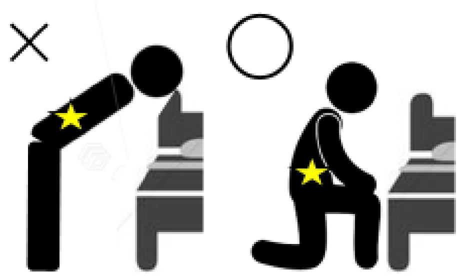

Figure 1. Good and bad motion posture during bedmaking.

Several points are related to the use of biomechanics to prevent lower back pain. One is to align the height of a

Manuscript received July 1, 2019; revised December 21, 2019.

doi: 10.18178/ijlt.6.1.43-46

nurse's center of gravity (COG) with the object's COG. The forward bending posture (Fig. 1-right) is not good because it causes lower back pain when a nurse makes a bed. A nurse opens both legs and bends the knees (Fig. 1-left), so that the height of the COG can be adjusted to the bed. This posture is suitable for preventing lower back pain.

B. Participants

In this study, 31 first-grade nursing students participated. They had already learned about bedmaking and using biomechanics.

C. Protocol

First, researchers set the bed and an iPad camera in place and chose the standing position of each participant (Figures 2-a,c). Participants showed some aspects of bedmaking: putting the side sheets under the bed (about 10 s). Then, researchers used an iPad camera to record the motion.

Under normal circumstances, a nurse should change the bed height to fit their own height. However, to ease measurement of changes in the COG, the bed height was left unchanged as 65 cm for this study (Fig. 2-b).

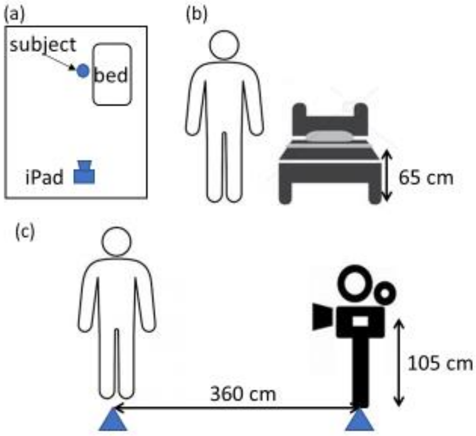

Figure 2. Experimental diagram: (a) top view, (b) front view, and (c) side view.

D. Analysis

Video images were analyzed using the human pose estimation system developed by Fujitsu Advanced Engineering Ltd. This system can detect body joints and can calculate the COG from joint location (patent applied).

To compare the COG shown by participants who were evaluated as passing (Good group) with those shown as failing (Bad group), paired t-tests and two-way repeated ANOVA were used. Statistical analyses were conducted using software (SPSS ver. 23; IBM, Tokyo, Japan). We inferred results for which $p < 0.05$ as statistically significant.

E. Ethical Consideration

After participants received an explanation of the research purpose and the experimental protocol from researchers, they gave written informed consent before participation in this study. This study was approved by the Ethics Committee of Kyoto Koka Women's University (No. 075).

III. Results

A. Characteristics of Participants

We analyzed 16 participants excluding 15 participants because of their video's defect. The heights of the 16 participants were 159.3±6.3 cm. Their COG were 94.0±6.7 cm. No significant difference was found between the heights of the Good group and Bad group members (Good group n = 9: 158.6±5.7 cm, Bad group n = 7: 160.1±7.3 cm, p = .632, t = -0.490).

B. Typical Examples

Fig. 3 shows typical good and bad examples. This image shows the motion posture during bedmaking. Addition of the skeleton line on the picture highlighted the COG position.

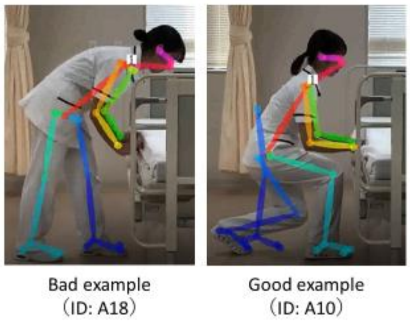

Figure 3. Typical examples.

Fig. 4 depicts the change in the COG of examples. The Good sample (ID: A10) lowered the COG more than 20 cm. By contrast, the Bad sample (ID: A18) lowered the COG only about 10 cm. Results show that the human pose estimation system can calculate the COG accurately.

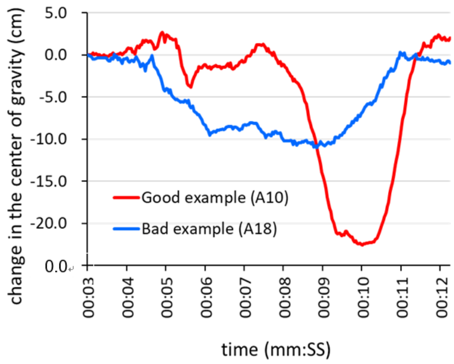

Figure 4. Change in the center of gravity (typical example).

C. Comparison of Good Group and Bad Group Findings

The change in the COG (from standing posture to motion posture) is presented in Fig. 5. Results of two-way repeated ANOVA revealed the main effect of the teacher's evaluation as p = .354, F (1, 14) = 0.918, the main effect of time as p < 0.001, F (1, 14) = 592.891, and interaction of teacher's evaluation*time: as p < 0.001, F (1, 14) = 28.811. In brief, the Good group significantly lowered their COG compared to the Bad group during motion.

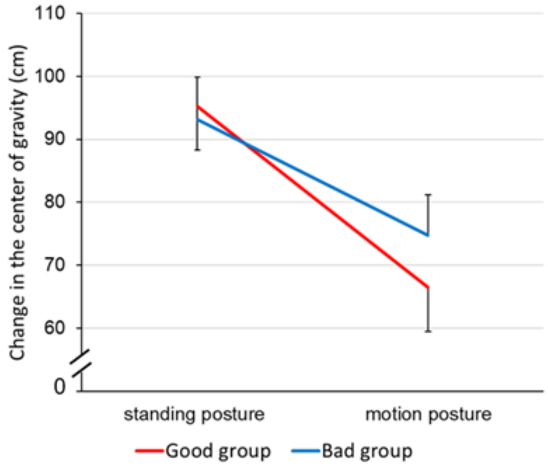

Figure 5. Good group and bad group results.

D. Detailed Analysis by Case

Table I presents data of all participants. The Good group lowered the center of gravity from standing posture to motion posture by more than 22 cm. The difference between standing and motion posture is affected by their height. Therefore, the difference to height ratio is calculated. Results show that the Good group lowered the COG more than 14% of their own height.

How high participants lowered the COG until (=motion posture) is important as an point of evaluating whether students use biomechanics. According to the principle, participants must lower the COG to the bed height (=65 cm). Despite the principle, some participants who performed inadequately lowered their COG were included in the Good group, for example ID: A4.

IV. Discussion

This trial experiment demonstrated that the human pose estimation system can calculate the COG accurately during motion. Results clarified that the teacher evaluated students who lowered the COG more than 23 cm (15% to height ratio) as passing. In this way, the human pose estimation system might enable evaluation of student motion postures in the same manner as a teacher's evaluation by deciding the judgment criteria.

Considering these results, some difficulties will be resolved by digitalization of the COG: teachers need much time for evaluation and multiple teacher evaluations lack consistency. Teachers can specifically evaluate parts that can not be judged by PC if the system can automatically evaluate motion posture. Furthermore, results of this study revealed that the teacher specifically examined only the difference between the standing posture and motion posture, and was unable to evaluate the degree to which students lowered the center of gravity. Evaluation by visual judgment was easy depending on the student height. Using this analytical system, objective evaluation becomes possible irrespective of the student height.

TABLE I. DATA OF ALL PARTICIPANTS

ID	Height (cm)	Height of the center of gravity (cm)		Difference Standing − motion (cm)	Difference to height ratio (%)	Judgement by teacher
		Standing posture	Motion posture			
A18	157	88	77	11	7	×
A19	162	96	83	14	9	×
A6	148	85	69	15	10	×
A15	158	91	73	18	11	×
A21	155	91	71	20	13	×
A16	164	108	87	22	13	×
A7	168	96	75	22	13	×
A23	157	92	70	22	14	×
A8	158	91	69	22	14	×
A17	155	92	69	23	15	○
A10	152	88	63	25	17	○
A9	166	97	69	28	17	○
A4	167	108	80	29	17	○
A20	154	93	61	31	20	○
A11	157	90	58	32	20	○
A12	170	98	66	32	19	○

Several educational effects can be anticipated from using this system. It is novel for students to see their videos with skeleton diagrams, thereby raising the awareness of learners. In the ARCS model, "attention" is the first element for improvement of a student's learning motivation [4]; its importance was clarified in many earlier studies [5]. Furthermore, students can view their skills objectively using the system. Therefore, it engenders development of metacognitive abilities for self-monitoring [6]. Kuiper and Pesut reported that metacognitive ability is fundamentally important to improve nursing skills [7].

Several limitations require some mention. First, the criterion of judgment when changing the bed's height according to each student's height is not clear because the bed height was not changed in this study. Second, physiological indicators such as muscle load are not measured. Third, this analytical system only supports two-dimensional movement. It cannot evaluate complicated motions. Fourth, this system requires time for analysis: the teacher cannot give immediate feedback to students when using this system. In the future, more experiments and improved analysis systems to overcome these limitations above should be performed.

V. Conclusion

We clarified that the Human pose estimation system can accurately calculate the center of gravity during motion. Results suggest that the system is applicable for the evaluation of nurse posture and for education of other nursing skills.

Conflict of Interest

The authors declare no conflict of interest associated with this manuscript.

Author Contributions

Tokunaga conducted the research; Saito and Tsurumaki developed the human pose estimation system; Nishimura and Itoi analyzed the data; Kurushima advised the discussion of results; Nishimura wrote the paper; all authors had approved the final version.

Acknowledgment

We are extremely grateful to Fujitsu Advanced Engineering Limited for their support in performing this study.

References

[1] K. G. Davis and S. E. Kotowski, "Prevalence of musculoskeletal disorders for nurses in hospitals, long-term care facilities, and home health care: A comprehensive review," *Human Factors*, vol. 57, no. 5, pp. 754-792, 2015.

[2] A. Nelson, *et al*., "Development and evaluation of a multifaceted ergonomics program to prevent injuries associated with patient handling tasks," *International Journal of Nursing Studies*, vol. 43, pp. 717-733, 2006.

[3] J. N. Hodder, S. N. Mackinnon, A. Ralhan, and P. J Keir, "Effects of training and experience on patient transfer biomechanics," *International Journal of Industrial Ergonomics*, vol. 40, pp. 282-288, 2010.

[4] J. M. Keller, "Development and use of the ARCS model of instructional design," *Journal of Instructional Development*, vol. 10, no. 3, pp. 2-10, 1987.

[5] K. Li and J. M. Keller, "Use of the ARCS model in education: A literature review," *Computer & Education*, vol. 122, pp. 54-62, 2018.

[6] G. Schraw, K. J. Crippen, and K. Hartley, "Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning," *Research in Science Education*, vol. 36, pp. 111-139, 2006.

[7] R. A. Kuiper and D. J. Pesut, "Promoting cognitive and metacognitive reflective reasoning skills in nursing practice: Self-regulated learning theory," *Journal of Advanced Nursing*, vol. 45, no. 4, pp. 381-391, 2004.

M. A. Makoto Nishimura, Master of Human health science, now is a Assistant Professor of the Department of Fundamental Nursing, School of Health Science, Kyoto Koka Women's University. She earned her Master of Human Health Science degree at Kyoto University Graduate School of Medicine. Her research interests are circadian rhythm, sleep and fundamental nursing education.

M. A. Makiko Itoi, MA of Nursing, now is a Assistant Professor of the Department of Fundamental Nursing, School of Health Science, Kyoto Koka Women's University. She earned her Master of Human Health Science degree at Kyoto University Graduate School of Medicine. Her research Interests are Feelings and discharge support of infants and their family.

Dr. Kiyoko Tokunaga, Ph.D. of Human Science, is an Associate Professor of the Department of Fundamental Nursing, School of Health Science, Kyoto Koka Women's University. She earned her Master of Nursing degree at Kitasato University Graduate School of Nursing, Doctor's degree (Ph.D.) at Osaka University Graduate School of Human Sciences. Her research interests are Method development and evaluation of nursing skill education using ICT. The use of collaborative learning put into nursing skill education.