


ORIGINAL ARTICLE

# Effects of differences in wiping pressure applied by nurses during daily bed baths on skin barrier function, cleanliness, and subjective evaluations

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## Abstract

**Aim:** To clarify the actual condition and examine the effects of differences in wiping pressure applied by clinical nurses during daily bed baths on skin barrier function, cleanliness, and subjective evaluations.

**Methods:** For the purposes of the present quasi-experimental interventional study, “wiping pressure” was defined as the “force applied vertically to the skin surface during bed baths.” Two types of bed baths, one using ordinary wiping (pressure: 23–25 mmHg) and the other using weak wiping (pressure: 12–14 mmHg), were performed on the forearms (right and left) of 30 healthy adult men and women, and the effects on transepidermal water loss, stratum corneum hydration, cleanliness, and subjective evaluations were examined.

**Results:** The results showed no differences between ordinary and weak wiping pressure in regard to the effects on skin barrier function and cleanliness. In terms of subjective evaluations, a significant association was seen between wiping pressure and the “sensation of having dirt removed” ( $P = .036$ ). Regarding “degree of pain,” some participants reported that the wiping pressure felt “slightly painful” under both conditions (ordinary: 31.1%; weak: 10.7%), while some with sensitive skin reported feeling pain even during weak wiping pressure.

**Conclusions:** The results of the present study suggest that skin assessments should be performed before and after bed baths, and that wiping pressure should be controlled and evaluated while considering the patient's feelings.

## KEYWORDS

baths, nurses, pressure, skin barrier, skin care

## 1 | INTRODUCTION

Bed baths are a type of hygienic care performed to maintain the cleanness of a patient's skin. This nursing skill is routinely performed for patients who have difficulties taking a bath (Matsumoto, Ogai, Ohashi, & Tanaka, 2018; Perry & Potter, 2002). Bed baths are needed for

such patients to remove dirt from the skin and mucous membranes and ensure good hygiene while effectively maintaining the skin barrier function (Cowdell & Steventon, 2013; Ersser, Getliffe, Voegeli, & Regan, 2005; Gillis et al., 2016; Matsumoto et al., 2018). The skin barrier primarily resides in the stratum corneum, the thin outermost layer of the epidermis. It is a natural frontier

between the inner organism and the environment that functions to prevent pathogen invasion and loss of skin moisture (Darlenski & Fluhr, 2012; Du Plessis et al., 2013; Ersser et al., 2005; Luebberding, Krueger, & Kerscher, 2013; Paul et al., 2011; Tagami, 2014). It is generally accepted that impairment of the skin barrier function results in diseased and damaged skin, including scales, dryness, and enhanced sensitivity (Gillis et al., 2016; Lichterfeld, Lahmann, Blume-Peytavi, & Kottner, 2016; Luebberding et al., 2013).

On the other hand, it has been suggested that the skin barrier function is damaged (Du Plessis et al., 2013) by friction irritation due to wiping (Voegeli, 2008) and the chemical irritants contained in detergents (Mason, 1997). Factors that cause frictional irritation to the skin include the frequency of wiping and the material of the towel (Voegeli, 2008). Above all, “wiping pressure” on the skin during bed baths can be considered a direct factor of friction irritation. Excessive wiping force and friction may lead to skin damage such as skin tears. Bryant and Rolstad (2001) also reported that bed baths using a washcloth constitute a risk factor for skin tears. In particular, because bed baths are frequently given to elderly patients and those in the intensive care unit (ICU) with high skin vulnerability (Coyer, O’Sullivan, & Cadman, 2011; Gillis et al., 2016; Kottner, Lichterfeld, & Blume-Peytavi, 2013; Larson et al., 2004; Matsumoto et al., 2019), it is considered that the risk of skin damage such as skin tears is increased among such patients (Kottner et al., 2013; Lichterfeld, Surber, Peters, Blume-Peytavi, & Kottner, 2015; Shishido & Yano, 2017). It is therefore recommended to minimize force and friction when bathing patients to maintain skin integrity (Bryant & Rolstad, 2001; Cowdell et al., 2016).

Shishido and Yano (2017) reported that applying a hot towel for 10 s to the skin of elderly nursing home residents during bed baths can increase suppleness, thereby protecting the skin from the friction irritation resulting from wiping. Gillis et al. (2016) reported that the use of a disposable wash glove did not increase the risk for dry skin compared with traditional washing methods. In addition, Matsumoto et al. (2019) suggested that compared with towel baths, disposable baths significantly reduced the number of *Staphylococcus aureus* infections and effectively maintained the stratum corneum hydration. However, none of these previous studies has investigated the effects of bed baths after quantifying and controlling wiping pressure.

Therefore, the actual wiping pressure applied by clinical nurses has not been clarified. Furthermore, to our knowledge, no studies have sought to clarify the criteria for wiping pressure and its effects in terms of providing comfort and removing dirt without damaging the patient’s skin. The goals of the present study were to

clarify the actual condition of and examine the effects of differences in wiping pressure applied by clinical nurses during daily bed baths on skin barrier function, cleanliness, and subjective evaluations.

Hence, this study was carried out in the following two phases.

Phase I: to clarify the wiping pressure applied by clinical nurses during daily bed baths.

Phase II: to examine the effects of differences in nurses’ wiping pressure on skin barrier function, cleanliness, and subjective evaluations.

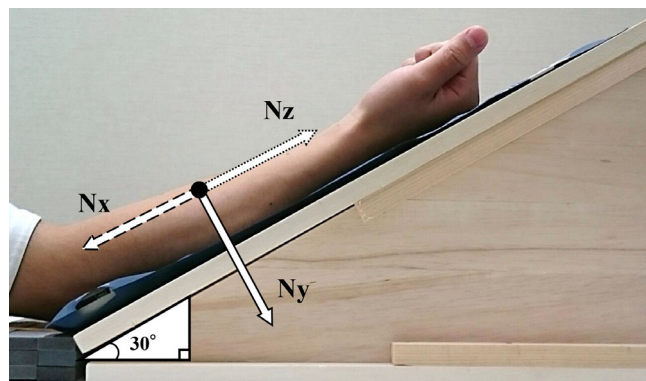
Clarifying the abovementioned effects could lead to the establishment of wiping techniques that are more appropriate for patients’ various skin conditions.

## 2 | OPERATIONAL TERMS

### 2.1 | Wiping pressure

“Wiping pressure,” which is defined as the force applied vertically to the skin surface during bed baths ( $N_y$ ) (Figure 1), is affected by both the speed and direction of wiping, the material of the washcloth used, the area in contact with the skin, and the wiped part of body. If these conditions are controlled for and the force ( $N$ ) in the direction of gravity of the forearm is eliminated, the approximate wiping pressure can be directly measured using a body pressure mat such as SR Soft Vision (SVZB4545L; Sumitomo Riko Co. Ltd., Komaki, Japan). SR Soft Vision can measure the pressure distribution from the vertical direction with a measurable pressure of 20–200 mmHg.

The arm of the participant was fixed on a table (bed bath table) at an angle of 30° and a bed bath was



**FIGURE 1** Definition of “wiping pressure”.  $N_x$ , driving force: force applied horizontally to the skin surface during bed baths and depending on wiping pressure;  $N_y$ , wiping pressure: force applied vertically to the skin surface during bed baths;  $N_z$ , frictional force: force applied oppositely to the driving force, regarded as equal because of equal wiping speed

performed. The arm is fixed at an angle because the nurses wipe the patient's arms while bending and supporting their elbow on the bed while in a standing position, and this setup was considered more clinical. An arm angle of 30° was also determined to not be a burden for the subject.

### 3 | PHASE I: INVESTIGATION OF WIPING PRESSURE

#### 3.1 | Methods

##### 3.1.1 | Study design and participants

This was an investigative study. The participants were 60 nurses with 3 or more years of clinical experience in General Hospital A (240 beds). The reason for selecting nurses with 3 or more years of clinical experience is that they are considered to be “competent,” “proficient,” or “expert” nurses (Benner, 1984). In each session, all nurses performed three types of bed baths on the simulated patient's forearm: ordinary pressure (ordinary wiping pressure), weak pressure (such as that to be used on patients with vulnerable skin), and strong pressure (such as that to be used on patients with skin contamination).

In addition, this hospital is located in a local city in northern Japan, and is characterized by a large number of elderly patients, as 50.3% or more of discharged patients in 2017 were over 70 years of age.

The nursing administrator was asked to select individuals meeting the study criteria while considering their age and affiliated ward. The study aims and experimental methods were explained orally and in writing to those who expressed an interest in participating.

##### 3.1.2 | Measures

###### *Bed bath methods*

Following the definition of wiping pressure, the forearm of the simulated patient (one healthy adult male) was placed on the bed bath table in flexion. The body pressure mat was placed between the patient's forearm and the bed bath table.

Cotton washcloths (size: approximately 32 × 32 cm; weight: 37.0 g) were prepared for the three types of bed baths in accordance with a previous study (Shishido & Yano, 2017). For wiping, the washcloths were saturated with water, wrung out until reaching a final weight of 88.0 ± 2.0 g, and then folded into eight equal parts (10 × 15 cm).

The nurses were asked to wipe three times from the peripheral to the central direction at a rate of one wipe per second. The three types of bed baths were conducted in random order.

##### 3.1.3 | Data collection

###### *Wiping pressure*

The three types of pressure were measured (in mmHg) using the body pressure mat, as described above. Only the wiping pressure was calculated, excluding the weight of the forearm. The mean of the three wiping pressures was taken as the wiping pressure of each nurse.

###### *Questionnaire*

A questionnaire was also administered to clarify the years of clinical experience and clinical area of each nurse.

##### 3.1.4 | Statistical analysis

All data are shown as the mean and standard deviation (*SD*). One-way analysis of variance (ANOVA) and Tukey–Kramer's honestly significant difference (HSD) test were performed on the means. All data analyses were conducted using SPSS Statistics (v. 25 for Windows; IBM Corporation, Armonk, NY, USA), and statistical significance was set at  $\alpha = .05$ .

##### 3.1.5 | Ethical considerations

The nursing administrators were asked to select individuals meeting the study criteria. The study aims and experimental methods were explained orally and in writing to those who expressed an interest in participating. Participants were also informed that they would not be penalized if they refused to participate, that they could withdraw from the study at any time, and that their anonymity would be protected. Those who signed a consent form were included in the study.

This study was approved by the ethics review boards of the authors' affiliated university and the participating facility (reference No.18–2), and was performed in accordance with the Declaration of Helsinki.

#### 3.2 | Results

##### 3.2.1 | Participants' characteristics

The study was conducted in June 2018. In total, 55 nurses were included in the analysis, after excluding five who had missing data. The nurses' mean (*SD*) years of experience was 19.3 (10.7) years. The distribution of years of experience was wide: 11 nurses had >3 years and < 10 years; 20 had >10 years and < 20 years; 11 had >20 years and < 30 years; and 13 had >30 years.

### 3.2.2 | Wiping pressure provided by nurses

Wiping pressure was significantly higher ( $P < .001$ ) in the ordinary type (mean [ $SD$ ]: 23.8 [9.8] mmHg, 95% confidence interval [ $CI$ ]: 21.2–26.4) and the strong type (26.0 [9.3] mmHg, 23.5–28.5) compared with the weak type (13.1 [7.3] mmHg, 11.1–15.0) (Table 1). The ordinary and strong types did not differ significantly ( $P = .368$ ). No significant relationship was found between each pressure type and years of clinical experience.

### 3.3 | Brief summary

The results revealed no significant difference between the ordinary and strong types, but the wiping pressure in these types was significantly higher than that in the weak type. Therefore, in Phase II, we compared ordinary with weak wiping pressure in terms of the effects on skin barrier function, cleanliness, and subjective evaluations. The reason for selecting these wiping pressures is that it was considered that there are few circumstances that require wiping strongly in the clinical setting. In clinical practice, elderly people and ICU patients with high skin vulnerability have many opportunities to be given bed baths (Gillis et al., 2016; Kottner et al., 2013; C. Matsumoto et al., 2018; Shishido & Yano, 2017). It has been reported that compared with that of healthy adults, the skin barrier function of elderly people declines because of qualitative differences due to age-related changes (Chang, Wong, Endo, & Norman, 2013; Gillis et al., 2016; Kottner et al., 2013; Matsumoto et al., 2018; Shishido & Yano, 2017). Therefore, clinical nurses who frequently perform bed baths for the elderly tend to avoid wiping strongly in consideration of the vulnerability of their skin, even when it is heavily soiled by blood or excrement. We considered that nurses increase the actual amount of wiping and use of cleaning agents instead of pressure (Bleasdale et al., 2007; Nerandzic, Rackaityte, Jury, Eckart, & Donskey, 2013), even if a patient has severe skin contamination.

## 4 | PHASE II: EFFECTS OF DIFFERENCES IN NURSES' WIPING PRESSURE ON SKIN BARRIER FUNCTION, CLEANLINESS, AND SUBJECTIVE EVALUATIONS

Following the results of Phase I, we compared ordinary with weak wiping pressure in terms of the effects on skin barrier function, cleanliness, and subjective evaluations.

## 4.1 | Methods

### 4.1.1 | Study design

This study involved a quasi-experimental design that enabled participants to experience two study protocols. Each participant experienced two different types of bed baths: wiping with ordinary pressure (Ordinary WIPE) and wiping with weak pressure (Weak WIPE). Each participant received a bed bath with Ordinary WIPE and Weak WIPE randomly assigned to the left and right forearms on the same day. They were then randomly allocated to two conditions: one in which the first type of bed bath preceded the second type, or another in which this sequence was reversed. The two conditions were conducted in random order.

### 4.1.2 | Participants

Study volunteers were recruited from among students at a national university. In total, 30 healthy students in their 20s (15 men, 15 women) agreed to participate in the study. The eligibility criterion was having skin with a normal appearance and sensation. Potential participants were excluded if the target area demonstrated swelling, redness, rashes, wounds, allergic reactions, itchy sensations, or rough or cracked surfaces, and/or required ointment application. In addition, the participants were required to refrain from consuming alcohol within 8 hr of the start of the experiment. On the day of the experiment, participants were instructed to refrain from eating spicy food or drinking large quantities of caffeinated beverages, performing strenuous exercise that might cause perspiration, and eating within 1 hr of the start of the experiment.

G Power software (ver. 3.19) (Faul, Erdfelder, Lang, & Buchner, 2007) was used to determine the sample size; the minimum sample size was calculated as 31 with the following settings: a significant difference between two dependent means (matched pairs) of 0.05, a power of 0.90, and an effect size of 0.60. The effect size was assumed to be 0.60 based on our pre-study research. Among the 31 individuals recruited, one was deemed unsuitable based on the eligibility criteria; thus, 30 students were chosen as participants.

### 4.1.3 | Measures

#### *Environmental setting*

All measurements were obtained from 10:00 a.m. to 5:00 p.m. To ensure the uniformity of the experimental

**TABLE 1** Characteristics of wiping pressure provided by nurses and comparison of the three types ( $n = 55$ )

Type	Wiping pressure (mmHg)		
	Mean (SD)	Median (IQR)	95% CI
Strong	26.0 (9.3)	25.5 (18.5, 32.8)	[23.5, 28.5]
Ordinary	23.8 (9.8)	* 22.8 (16.8, 28.0)	[21.2, 26.4]
Weak	13.1 (7.3)	10.8 (7.8, 17.0)	[11.1, 15.0]

Notes: CI, confidence interval; IQR, interquartile range; Ordinary, ordinary wiping pressure; SD, standard deviation; Strong, strong wiping pressure (such as that to be used on patients with skin contamination); Weak, weak wiping pressure (such as that to be used on patients with vulnerable skin). One-way analysis of variance (ANOVA) and Tukey–Kramer's honestly significant difference (HSD) test.

\* $P < .001$ .

conditions, room temperature and humidity were maintained at 22–24°C and 40–60%, respectively.

#### *Preparation of towels for use during bed baths*

Two cotton washcloths were prepared for Ordinary and Weak WIPE under the same conditions as those for Phase I. A towel warmer (TW-12S/F; World JB Co., Ltd., Tokyo, Japan) with an internal temperature of 60–70°C was used to warm the washcloths, which were then folded in the same way as that in Phase I, for 30 min, until the internal temperatures were unified to about 50°C.

#### *Bed bath methods*

On the participants' left and right forearms (in flexion), Ordinary and Weak WIPE were performed three times from the peripheral to the central direction using washcloths made from the same material. Ordinary pressure was 23–25 mmHg, and weak pressure was 12–14 mmHg. To unify the pressures, wiping was performed while carefully checking whether the two wiping pressures were reproduced using the body pressure mat, and whether the area of washcloth in contact with the skin was controlled. The wiping speed was sufficiently trained and unified by the main researcher so as to be once per second. The wiping pressure was unified as much as possible, and each method was conducted by the main researcher to unify the procedure.

### **4.1.4 | Data collection**

The study protocol was as shown in Figure 2.

#### *Participants' characteristics*

Participants completed the questionnaire before starting the bed baths. The questionnaires were administered to

collect information on the participants' gender, age, body mass index (BMI), required ointment application, skin disease or disorder in the forearm, and intake of stimulants such as alcohol, caffeine, and spices prior to the study.

#### *Transepidermal water loss (TEWL)*

A Tewameter® TM300 (Courage + Khazaka, Cologne, Germany) was used to measure TEWL at the center of the inner forearm. TEWL is defined as the flux density of water that diffuses from the dermis and epidermis through the stratum corneum to the skin. It is one of the most important skin barrier characteristics. Increased TEWL seems to be associated with skin barrier dysfunction. Measurement of TEWL is based on the principle of the evaluation of the water vapor pressure gradient immediately above the skin surface. The measurements were carried out continuously for 30 s, and the average value was used. TEWL is displayed in  $\text{g m}^{-2} \text{hr}^{-1}$  (Akdeniz, Gabriel, Lichterfeld-Kottner, Blume-Peytavi, & Kottner, 2018; Darlenski & Fluhr, 2012; Du Plessis et al., 2013; Rogiers, 2001; Rosado, Pinto, & Rodrigues, 2005; Shishido & Yano, 2017; Voegeli, 2008).

The main researcher performed all measurements. The reference values for TEWL provided by the manufacturer were: 0–10  $\text{g m}^{-2} \text{hr}^{-1}$  for very good, 10–15  $\text{g m}^{-2} \text{hr}^{-1}$  for good, 15–25  $\text{g m}^{-2} \text{hr}^{-1}$  for ordinary, 25–30  $\text{g m}^{-2} \text{hr}^{-1}$  for dry, and >30  $\text{g m}^{-2} \text{hr}^{-1}$  for dangerously dry.

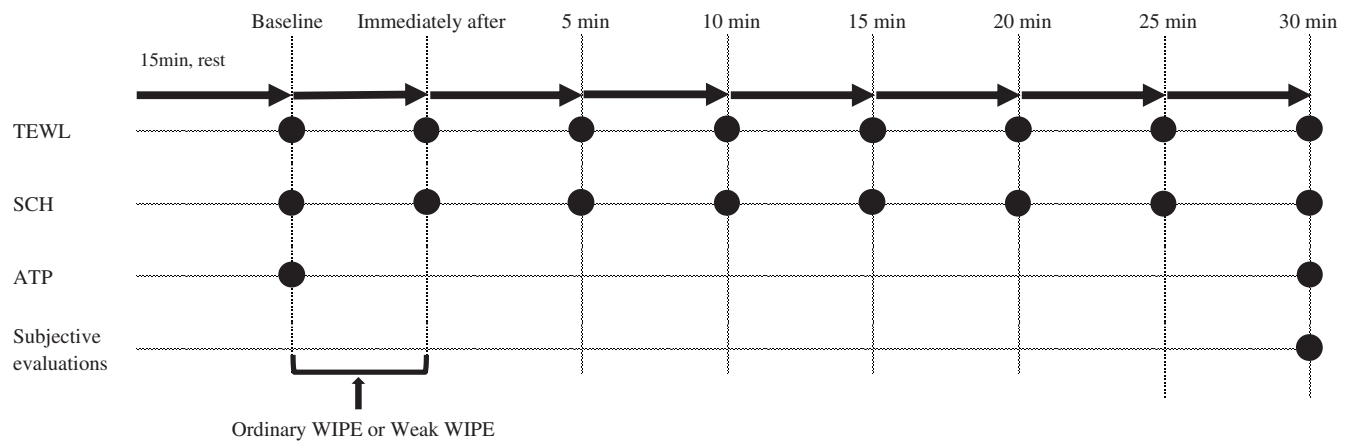
#### *Stratum corneum hydration (SCH)*

A Corneometer® CM825 (Courage + Khazaka) was used to measure SCH at the center of the inner forearm. This instrument measures the electrical capacitance of the skin, with a reduction in hydration producing a reduction in capacitance. It has become the standard measure of skin hydration in dermatological research. The more water contained in the epidermis, the larger the electrostatic capacity becomes. SCH is displayed in arbitrary units (AU) (Berardesca et al., 1997; Darlenski & Fluhr, 2012; Du Plessis et al., 2013; Shishido & Yano, 2017; Voegeli, 2008).

The main researcher performed all measurements to avoid errors due to procedural deviation. The reference values for SCH provided by the manufacturer were: >50 AU for sufficient moisture, 35–50 AU for dry, and <35 AU for very dry.

#### *Adenosine triphosphate (ATP)*

ATP is a substance that is routinely present as an energy source for organisms. It is an indicator of the degree of contamination from organic residues and microorganisms. The measurement of skin cleanliness used the ATP wiping method (Ishii, Nakada, Kobayashi, & Kawashima,



**FIGURE 2** Study protocol. •, point of measurement; ATP, adenosine triphosphate; Ordinary WIPE, wiping with ordinary pressure (23–25 mmHg); SCH, stratum corneum hydration; TEWL, transepidermal water loss; Weak WIPE, wiping with weak pressure (12–14 mmHg)

2019; Shishido et al., 2015). In this method, the measurement area is wiped with a dedicated cotton swab. ATP is reacted as a reagent, and the relative light unit (RLU) is quantified to evaluate skin cleanliness. The lower the RLU value, the cleaner the skin.

On the participants' forearms (in flexion), a 45-mm square frame was placed around the center of the wrist and elbow socket to mark four points, and the inside of this square was used as the ATP measurement area. The 3M™ Clean-Trace™ ATP Monitoring System (3M Japan Ltd., Tokyo, Japan) was used to measure ATP.

The ATP reference values for worker's palm provided by the manufacturer were:  $\leq 1,000$  for "Pass," 1,001–1,999 for "Caution," and  $\geq 2000$  for "Fail." These are the only ATP values provided for the human body by the manufacturer.

#### Subjective evaluations

All participants completed questionnaires after the experiment. Each participant rated the sensation of having dirt removed after wiping on a four-point scale (1 = completely removed, 2 = removed, 3 = not really removed, 4 = not removed at all). Participants also rated their degree of pain during wiping (1 = painless, 2 = almost painless, 3 = slightly painful, 4 = very painful) and their comfort level during wiping (1 = very pleasant, 2 = slightly pleasant, 3 = slightly unpleasant, 4 = unpleasant).

#### 4.1.5 | Statistical analysis

The intraclass correlation coefficient (ICC) was calculated for intra-rater reliability independently of the wiping pressure performed by the researcher. An ICC value of 0.61–0.80 indicates substantial reliability, and an ICC

value of 0.81–1.00 indicates almost perfect reliability (Landis & Koch, 1977).

All continuous variables are shown as the mean and *SD*. As the amount of change in TEWL and SCH were measured before and after wiping, the changes in values were obtained by subtracting the baseline value from the measurement value after wiping (after 5–30 min). For ATP, the rate of change was calculated before and after wiping.

TEWL and SCH were analyzed in a mixed-linear model for two-way repeated-measures ANOVA, and a Bonferroni correction was carried out to adjust for multiplicity. This statistical method uses all available data, can properly account for correlations between repeated measurements on the same subject, has greater flexibility to model time effects, and can handle missing data more appropriately. This flexibility makes it the preferred choice for the analysis of repeated-measures data (Gueorguieva & Krystal, 2004) in the field of nursing research (Shin, 2009). In the mixed-linear ANOVA model, condition (wiping pressure) and time were defined as a fixed factor, and subject was defined as a random factor. The factors in this ANOVA were "condition" (ordinary wiping pressure and weak wiping pressure conditions) and "time" (baseline and immediately after wiping [5–30 min]). For the interaction, "condition  $\times$  time" was set up. In this ANOVA, data at immediately after wiping were not included because it was considered that these data could have easily been affected by moisture and friction. If at least one of the factors or interactions was significant, a single-factor repeated-measures ANOVA and Tukey–Kramer's HSD test were used for multiple comparisons within the condition. Paired *t* tests were performed on the means to compare TEWL, SCH, and ATP at each measurement point between the two conditions. Fisher's exact test was used

to compare subjective evaluations between the two conditions.

Analyses were conducted using SPSS Statistics (v. 25 for Windows; IBM Corporation). Statistical significance was set at  $\alpha = .05$ .

#### 4.1.6 | Ethical considerations

The study aims and experimental methods were explained orally and in writing to those who expressed an interest in participating. Participants were also informed that they would not be penalized if they refused to participate, that they could withdraw from the study at any time, and that their anonymity would be protected. Those who signed a consent form were included in the study.

This study was approved by the ethics review board of the authors' affiliated university (reference No. 18-2), and was performed in accordance with the Declaration of Helsinki.

## 4.2 | Results

### 4.2.1 | Participants' characteristics

The present study was conducted between August and September 2018. In total, 28 participants (14 men [50.0%] and 14 women [50.0%], mean age [*SD*] 21.8 [1.4] years, mean BMI [*SD*] 21.4 [3.3] kg/m<sup>2</sup>) were included in the analysis after excluding two who were judged to have excessive sweating. No significant gender differences were observed in TEWL, SCH, or ATP before wiping.

### 4.2.2 | TEWL

Although the main effect of time on TEWL was significant ( $F_{[6, 25]} = 27.9, P < .001$ ), that of condition was not ( $F_{[1, 27]} = 0.1, P = .740$ ). The interaction did not show a significant difference ( $F_{[6, 23]} = 0.7, P = .633$ ; Table 2).

In the time courses, TEWL at immediately after wiping was significantly higher than that at baseline under both conditions ( $P < .001$ ). In addition, TEWL at 5–30 min after wiping was significantly lower than that at immediately after wiping, but higher than that at baseline under both conditions ( $P < .01$ ).

Regarding the mean at each measurement time point, a significant difference was observed between the two conditions only at immediately after wiping, and that for Ordinary WIPE was significantly higher than that for Weak WIPE ( $P = .001$ ). Regarding the amount of change, a significant difference was observed only for that

between baseline and immediately after wiping, and that for Ordinary WIPE was significantly higher than that for Weak WIPE ( $P < .01$ ).

### 4.2.3 | SCH

Although the main effect of time was significant ( $F_{[6, 27]} = 10.7, P < .001$ ), that of condition was not ( $F_{[1, 27]} = 0.2, P = .645$ ). The interaction was not significant ( $F_{[6, 26]} = 1.9, P = .123$ ; Table 2).

Regarding the time courses, SCH at immediately after wiping was significantly higher than that at baseline under both conditions ( $P < .001$ ). In addition, under both conditions, SCH at 5–30 min after wiping was significantly lower than that immediately after wiping, but higher than that at baseline ( $P < .01$ ).

Regarding the mean at each measurement time point, a significant difference was observed between the two conditions only at immediately after wiping, and Ordinary WIPE was significantly higher than Weak WIPE ( $P = .017$ ). Regarding the amount of change, a significant difference was observed only in the amount of change between baseline and immediately after wiping, and that for Ordinary WIPE was significantly higher than that for Weak WIPE ( $P < .01$ ).

### 4.2.4 | ATP

The mean for ATP after wiping was significantly lower than that at baseline under both conditions ( $P < .001$ ; Table 3), but no significant difference was seen in the rate of change for ATP between the two conditions. The mean rate of change (*SD*) for ATP was 58.7 (24.8)% for Ordinary WIPE and 51.6 (27.0)% for Weak WIPE. According to the 3M Japan reference values, the mean ATP after wiping under Ordinary WIPE fell under the "Pass" category, whereas that of Weak WIPE fell under the "Caution" category. Each ATP value after wiping under Ordinary WIPE was classified as 78.6% for "Pass," 10.7% for "Caution," and 10.7% for "Fail," whereas each ATP value after wiping under Weak WIPE was classified as 67.9% for "Pass," 21.4% for "Caution," and 10.7% for "Fail."

### 4.2.5 | Subjective evaluations

#### *Sensation of having dirt removed*

Wiping pressure was significantly related to "sensation of having dirt removed" ( $P = .036$ ; Table 4). Regarding the percentage that answered "completely removed," Ordinary WIPE was 60.7%, whereas Weak WIPE was 32.1%.

**TABLE 2** Comparison of Ordinary WIPE and Weak WIPE in the time courses of TEWL and SCH (*n* = 28: 14 men, 14 women)

		Time							Main effect <sup>a</sup>		Interection <sup>a</sup> condition × Time	
		Baseline	Immediately after	5 min	10 min	15 min	20 min	25 min	30 min	Condition	Time	p
TEWL (g m <sup>-2</sup> hr <sup>-1</sup> )										<i>F</i> (df)	<i>F</i> (df)	<i>p</i>
Ordinary WIPE	Mean (SD)	6.9 (1.5)	26.7 (10.5)	9.0 (2.0)	8.4 (2.1)	8.5 (1.7)	8.5 (1.4)	9.0 (1.5)	9.1 (1.2)			
	95% CI	6.4–7.5	22.6–30.8	8.2–9.8	7.6–9.2	7.9–9.2	8.0–9.1	8.4–9.6	8.6–9.6			
Weak WIPE	Mean (SD)	7.4 (2.6)	21.3 (9.2)	8.7 (2.1)	8.2 (1.3)	9.0 (2.0)	8.8 (2.0)	9.0 (1.5)	8.8 (1.7)	0.1 (1,27)	27.9 (6,25)	<.001
	95% CI	6.4–8.4	17.8–24.9	7.9–9.5	7.7–8.7	8.2–9.7	8.1–9.6	8.4–9.6	8.1–9.5			
<i>p</i> -value <sup>b</sup>		.263	.001**	.426	.515	.184	.331	.911	.245			
SCH (AU)												
Ordinary WIPE	Mean (SD)	27.3 (6.0)	68.0 (14.4)	31.0 (6.0)	30.2 (5.7)	29.9 (5.7)	29.7 (5.9)	30.2 (6.0)	29.4 (5.5)			
	95% CI	24.9–30.0	62.3–73.5	28.6–33.2	28.0–32.4	27.7–32.1	27.4–31.9	27.9–32.6	27.3–31.6			
Weak WIPE	Mean (SD)	27.5 (6.6)	63.6 (16.1)	30.2 (5.5)	29.7 (5.9)	29.8 (6.3)	29.7 (6.0)	29.4 (6.2)	29.4 (5.5)	0.2 (1,27)	10.7 (6,27)	<.001
	95% CI	25.0–30.1	57.4–69.9	28.1–32.4	27.4–32.0	27.3–32.2	27.3–32.0	27.0–31.8	27.2–31.5			
<i>p</i> -value <sup>b</sup>		.678	.017*	.318	.446	.811	.976	.216	.958			

Notes: Data were shown as Mean (Standard deviation, SD), df, degree of freedom; Ordinary WIPE, wiping with ordinary pressure (23–25 mmHg); SCH, stratum corneum hydration; TEWL, transepidermal water loss; Weak WIPE, wiping with weak pressure (12–14 mmHg); CI, confidence interval. Interaction (condition × time) and main effect were analyzed in a mixed-linear model for two-way repeated-measures ANOVA, and a Bonferroni correction was carried out to adjust for multiplicity.

<sup>a</sup>In this ANOVA, data at immediately after wiping were not included because it was considered that these data could have easily been affected by moisture and friction.

<sup>b</sup>Paired *t*-tests.

\**P* < .05; \*\**P* < .01.

### Degree of pain

No significant difference in degree of pain was observed between the two conditions (Table 4). Nine participants (32.1%) under the Ordinary WIPE and three (10.7%) under the Weak WIPE answered “slightly painful.” Among these participants, the three who answered “slightly painful,” which was the lowest score in the subjective evaluations of the degree of pain in Weak WIPE, were regarded as Cases A, B, and C. Their time courses of TEWL and SCH were compared with the other 25 participants (Figures 3 and 4). The Cases were A (23 years old), B (20 years old), and C (22 years old), all of whom were women. The mean TEWL at 5–30 min in Cases A–C fell under the “very good” category according to the Courage + Khazaka reference values, while those of the SCH fell under the “dry” to “very dry” categories. These results were similar to the other 25 participants.

### Comfort level

No significant difference in comfort level was observed between the two conditions (Table 4). Moreover, 89.3% of those under the Ordinary WIPE and 96.4% under the Weak WIPE answered “very pleasant” and “slightly pleasant.”

## 4.2.6 | ICC

The ICCs for the intra-rater reliability of ordinary and weak wiping pressure were 0.78 ( $P < .001$ ) and 0.79 ( $P < .001$ ), respectively. The ICCs for the intra-rater reliability of Ordinary and Weak WIPE were both  $>0.7$ , reflecting sufficient reliability. In practice, the mean ordinary pressure ( $SD$ ) applied to all participants was 23.5 (3.9) mmHg, and the mean weak pressure was 12.8 (2.2) mmHg.

## 4.3 | Discussion

### 4.3.1 | Effects on skin barrier function

Currently, it is recommended that wiping pressure should minimize the wiping force and friction during bed baths because of concerns about direct skin threats (Bryant & Rolstad, 2001; Perry & Potter, 2002). Therefore, we expected that even if ordinary wiping was routinely performed by a clinical nurse, it would affect the skin barrier function more than weak wiping, which involves less physical stimulation. However, no significant effects of pressure were observed on skin barrier function. In addition, no significant difference was found between the two conditions for either TEWL or SCH at 5–30 min after wiping, which suggests that the

**TABLE 3** Comparison of Ordinary WIPE and Weak WIPE in the ATP ( $n = 28$ : 14 men, 14 women)

	Baseline (RLU)	After wiping (RLU)	Rate of change (%)
Ordinary WIPE	*		
Mean ( $SD$ )	2,793.8 (2,558.0)	866.5 (726.6)	58.7 (24.8)
Weak WIPE	*		
Mean ( $SD$ )	3,147.6 (4,391.9)	1,427.8 (2,169.1)	51.6 (27.0)
$p$ -value <sup>a</sup>	.488	.094	.304

Notes: ATP, adenosine triphosphate; Ordinary WIPE, wiping with ordinary pressure (23–25 mmHg); RLU, relative light unit;  $SD$ , standard deviation; Weak WIPE, wiping with weak pressure (12–14 mmHg).

<sup>a</sup>Paired  $t$ -tests.

\* $P < .001$ .

**TABLE 4** Comparison of Ordinary WIPE and Weak WIPE in the subjective evaluations

	Weak WIPE ( $N = 28$ )	Ordinary WIPE ( $N = 28$ )	$P$ -value <sup>a</sup>
Sensation of having dirt removed: $n$ (%)			
Completely removed	9 (32.1)	17 (60.7)	.036*
Removed	15 (53.6)	11 (39.3)	
Not really removed	4 (14.3)	0 (0.0)	
Not removed at all	0 (0.0)	0 (0.0)	
Degree of pain: $n$ (%)			
Painless	18 (64.3)	11 (39.3)	.099
Almost painless	7 (24.0)	8 (28.6)	
Slightly painful	3 (10.7)	9 (32.1)	
Very painful	0 (0.0)	0 (0.0)	
Comfort level: $n$ (%)			
Very pleasant	9 (32.1)	7 (25.0)	.638
Slightly pleasant	18 (64.3)	18 (64.3)	
Slightly unpleasant	1 (3.6)	3 (10.7)	
Unpleasant	0 (0.0)	0 (0.0)	

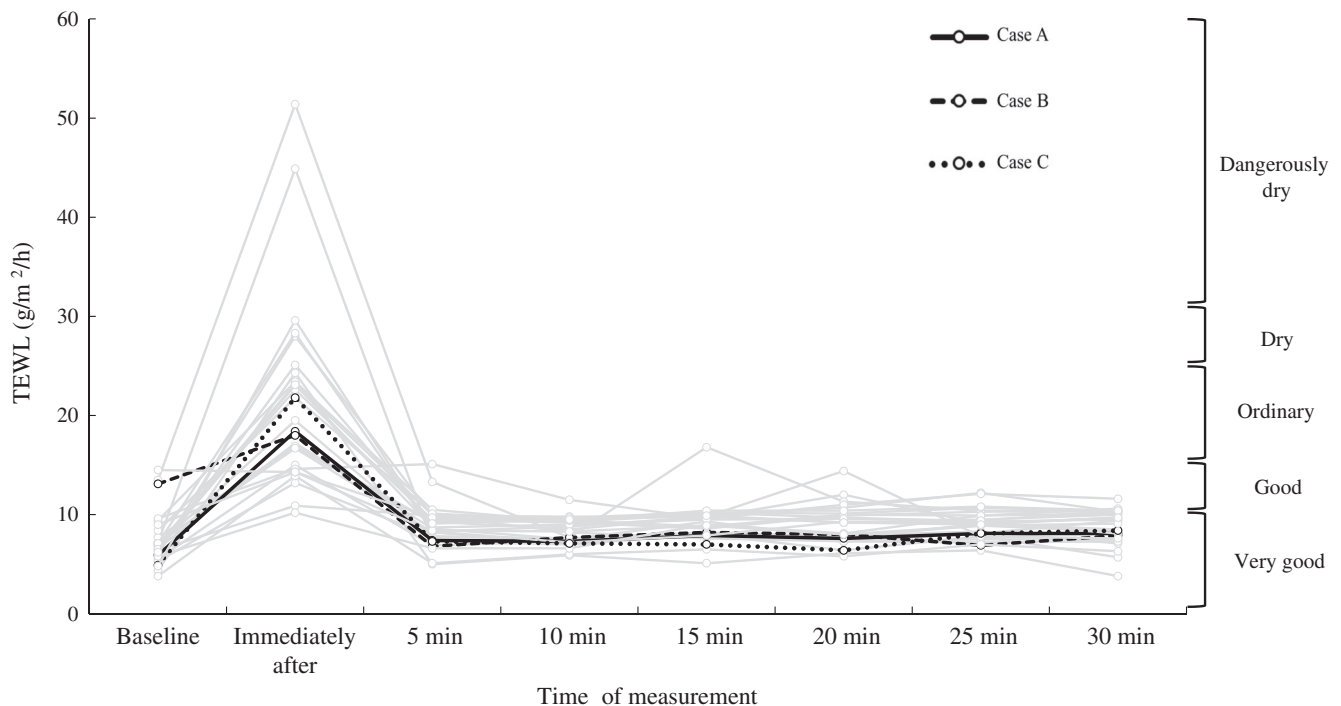
Notes: Ordinary WIPE, wiping with ordinary pressure (23–25 mmHg); Weak WIPE, wiping with weak pressure (12–14 mmHg).

<sup>a</sup>Fisher's exact test.

\* $P < .05$ .

wiping pressure applied by clinical nurses has no difference in regard to the effects on the skin barrier function.

TEWL at 5–30 min after wiping was significantly higher than that at baseline under both conditions. The wiping under both conditions might have led to increased TEWL, which indicates a breakdown of skin barrier function; however, SCH was also increased, which indicates improved skin barrier function. For these reasons, it is thought that the addition of water by wiping might have led to an



**FIGURE 3** Comparison of cases A–C and the other 25 participants in the time courses of TEWL under the Weak WIPE condition. Cases A–C, three participants who answered “slightly painful,” which was the lowest score in the subjective evaluations of the degree of pain under the Weak WIPE condition; TEWL, transepidermal water loss; Weak WIPE, wiping with weak pressure (12–14 mmHg)

increase in TEWL. The mean TEWL at 5–30 min after wiping fell under the “very good” category, according to the Courage + Khazaka reference values. Akdeniz et al. (2018) updated an existing systematic review and meta-analysis to provide TEWL reference values for healthy skin in adults. According to that report, the TEWL reference values in the left and right distal volar forearms were  $12.5 \text{ g m}^{-2} \text{ hr}^{-1}$  (95% CI: 8.3–16.7) and  $8.8 \text{ g m}^{-2} \text{ hr}^{-1}$  (95% CI: 7.6–10.0), respectively. From this, although the TEWL value after wiping (5–30 min) was significantly higher than that before wiping, the two types of wiping could not have negatively affected the skin barrier function. Therefore, the two wiping pressures applied by the nurses did not significantly differ in their effect on the skin barrier function.

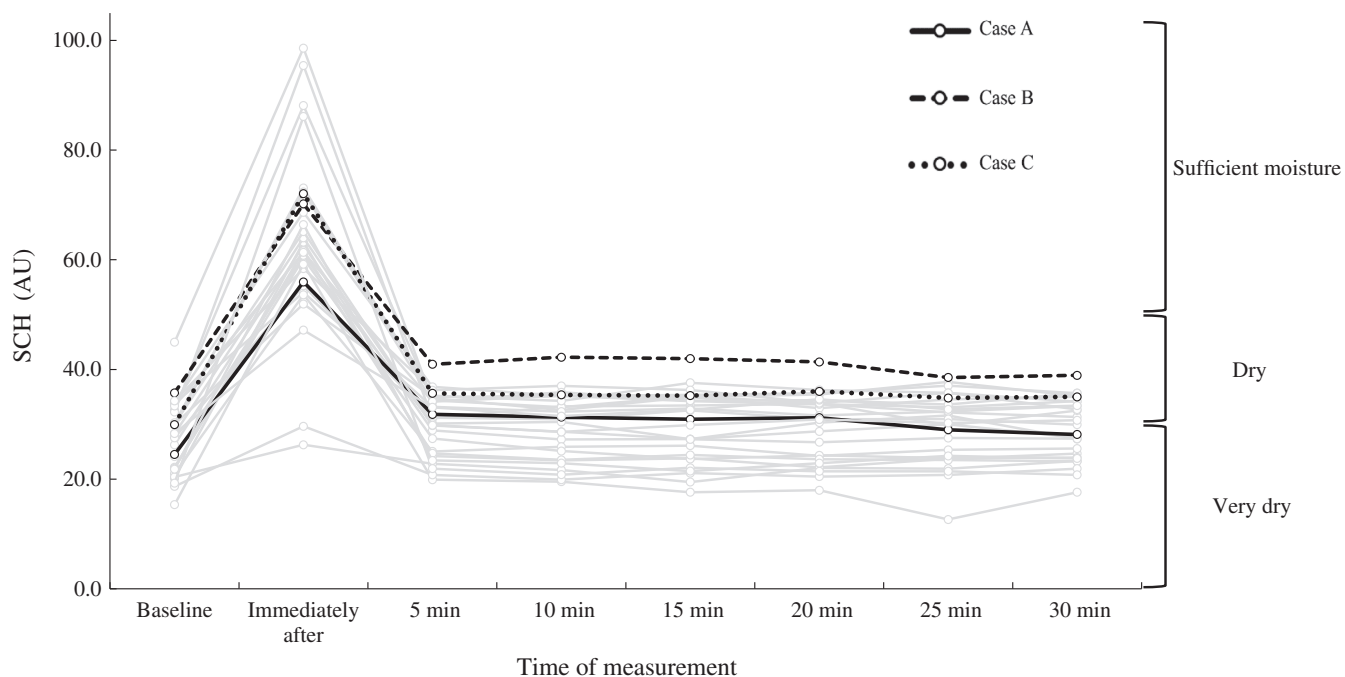
#### 4.3.2 | Effects on cleanliness and subjective evaluations

The mean ATP after wiping was significantly lower than that at baseline under both conditions. Only that of Ordinary WIPE fell under the “Pass” category; that of Weak WIPE fell under the “Caution” category. However, ATP in

the human body varies substantially; 21.4% of those under the Ordinary WIPE condition did not fall under the “Pass” category. In addition, no significant differences were found between the two conditions. Therefore, if the number of wipes is the same for healthy adults, both ordinary and weak wiping pressure can increase cleanliness.

In the subjective evaluations, wiping pressure was significantly related to “sensation of having dirt removed.” On the other hand, no significant difference was observed between the two conditions in “degree of pain” or “comfort.” It is assumed that ordinary pressure is more likely than weak pressure to result in the sensation of having dirt removed because ordinary pressure involves more pressure on the skin. Increasing wiping pressure is therefore suggested to be effective for patients to obtain a sense of being cleaner.

Some of the participants felt some degree of pain under both levels of pressure. Those who felt some pain under weak pressure might have had sensitive skin sensation because of a vulnerable skin barrier function. However, from the results in Figures 3 and 4, it could be judged that the time courses of TEWL and SCH in Cases A–C were the same as those in other participants. No adverse events occurred, even in participants with sensitive skin who felt some pain when wiped with weak



**FIGURE 4** Comparison of cases A–C and the other 25 participants in the time courses of SCH under the Weak WIPE condition. Cases A–C, three participants who answered “slightly painful,” which was the lowest score in the subjective evaluations of the degree of pain under the Weak WIPE condition; SCH, stratum corneum hydration; Weak WIPE, wiping with weak pressure (12–14 mmHg)

pressure, and no negative effects on the skin barrier function of Cases A–C were noted.

A previous study evaluated the skin barrier function in six parts of the body of 150 healthy women aged 18–80 years divided into five age groups with 30 participants each. The results suggested that the skin barrier function partly changes with aging (Luebberding et al., 2013). Therefore, when performing bed baths for elderly people with vulnerable skin (Farage, Miller, Berardesca, & Maibach, 2009; Kottner et al., 2013), it is quite possible that an impaired skin barrier function makes their feeling of discomfort and pain stronger than that experienced from ordinary pressure. It should be noted that even healthy adults may have sensitive skin. To provide safer and more comfortable bed baths, it appears necessary to conduct skin assessments before and after bed baths (Ersser et al., 2005; Lichterfeld et al., 2015) and to adjust and evaluate the wiping pressure together with patients. Furthermore, since all three people in the present study who felt slight pain, even under weak pressure, were women, there may be gender differences in regard to the sensation of wiping pressure.

#### 4.3.3 | Implications for clinical practice

In the case of healthy adults, as a result of comparing and examining ordinary and weak wiping pressure, it

was clear that there was no difference in the effects on skin barrier function and cleanliness. However, the range and *SD* of the wiping pressure applied by clinical nurses were large, which suggests large individual differences. One possible explanation for this issue is the lack of evidence for wiping pressure in previous studies or textbooks. Even though it is a direct factor in friction irritation to the skin, the only types of suggestions mentioned include “minimize force and friction” (Bryant & Rolstad, 2001; Cowdell et al., 2016) and “avoid vigorously rubbing the skin” (Lichterfeld et al., 2015). In nursing schools and clinical settings, nurses are not taught the criteria for wiping pressure and its effects in terms of providing comfort and removing dirt without damaging the patient’s skin. For these reasons, we infer that wiping pressure reflects individual experiences and the preferences of nurses, which suggests substantial variation. If the wiping pressure is high, friction irritation may be increased, which could damage the skin barrier function, even in healthy adults. Bryant and Rolstad (2001) also reported that bed baths using a washcloth constitute a risk factor for skin tears. Therefore, when selecting wiping pressures in the clinical setting, it is always necessary to check the patient’s skin sensation, to assess skin conditions before and after the bed bath, and to observe the skin reaction (Cowdell, 2011). It is also important to evaluate the wiping pressure together with the patients.

#### 4.3.4 | Study limitations

In the present study, since the participants were limited to healthy adults with a good skin condition, the effects of differences in wiping pressure on elderly people, whose skin barrier function is decreased because of age, as well as others with vulnerable skin, remain unclear. In the future, it will be necessary to conduct the same analyses in other populations and to examine the optimal and safe wiping pressure for a wider range of participants.

## 5 | CONCLUSION

Ordinary and weak wiping pressure routinely applied by clinical nurses did not significantly differ in their effects, but both conditions could increase cleanliness without negatively affecting skin barrier function when the participants were healthy adults.

In addition, no significant difference was found in “degree of pain” or “comfort” between the two conditions in the subjective evaluations, but wiping pressure was significantly related to “sensation of having dirt removed.” On the other hand, some participants with sensitive skin conditions felt some pain, even with weak wiping pressure.

Therefore, skin assessments should be performed before and after bed baths, and wiping pressure should be controlled and evaluated at the time of bed baths while considering the patient’s feelings.

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## DISCLOSURE

The authors declare no conflict of interest.

## AUTHOR CONTRIBUTIONS

I.K., S.Y., N.S., and R.Y. contributed to the conception and design of the study; I.K., S.Y., N.S., and C.M. contributed to the acquisition of the data; S.Y. contributed to the statistical analysis; I.K. conducted the statistical analysis; I.K. and R.Y. drafted the manuscript; R.Y. critically reviewed the manuscript and supervised the whole study process. All authors read and approved the final version of the manuscript.

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