Comparison of the Effects of Complete Bed Baths Using Towels with Different Surface Properties - Synthetic and Gauze -

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Abstract

Aim: To compare the effects of complete bed baths using towels (coarse synthetic/gauze) with different surface properties (such as the number of meshes on the surface).

Methods: Fifteen healthy male students who consented were treated with complete bed baths using the 2 types of towel on different days, and the effects were evaluated using the following indices: core body temperature, skin temperature, blood pressure, heart rate variability, skin moisture and oil contents, skin surface pH and cleanliness levels, short-version POMS-J, levels of wakefulness and relaxation, and texture rated on a Likert scale.

Results: Both types of towel led to an increase in the level of relaxation immediately after the bed bath, increases in the core body temperature and skin temperature, excluding that in peripheral regions, which persisted until the final point, and decrease in the skin oil content immediately after the bed bath (P=0.001 in all cases). When using the synthetic towels, the soft feel of the towel (P=0.001) and level of wakefulness decreased immediately after the bed bath (P=0.002), the systolic and diastolic blood pressure levels decreased at 15 minutes after the bed bath (P=0.011), and the skin moisture content decreased (P=0.001), while the skin surface pH level increased immediately after the bed bath(P=0.018). The results of subjective evaluation did not support the gauze towels in terms of comfort, except for the level of relaxation which increased immediately after the bed bath. When using the gauze towels, the diastolic blood pressure level increased immediately after the bed bath (P=0.002), the heart rate decreased until the final point (P=0.028), the parasympathetic activity level (HF) increased at 15 minutes after the bed bath (P=0.012), and the skin moisture content decreased until the final point (P=0.001), while the skin cleanliness level increased immediately after the bed bath (P=0.011), indicating that dirt had been effectively removed.

Conclusions: Compared with the synthetic towels, the gauze towels produced stronger tactile and pressure stimulation on their surface, resulting in poorer subjective evaluation results, but their effect of removing dirt from the skin was greater.

Key Words：synthetic towels, gauze towels, different surface properties, effects of complete bed baths

Introduction

In Japan's medical services, the sophistication and acceleration of medical care are resulting in the simplification of procedures and labor-saving in nursing care, making it difficult to ensure the quality of care. As a prime example of such a situation, complete bed baths for severely ill patients, which is an advanced nursing technique, are performed with only a few steamed cotton towels (cotton towels). However, the

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＜Received 11 October 2022＞　＜Accepted 10 January 2023＞

original purpose of nursing is to support the daily lives of care recipients, and the ward nurses involved in our national survey felt alarmed about the current situation in Japan, where patient hygiene care is neglected in practice settings[1]. In addition, our interview survey revealed that patients also feel that their hygiene needs are not fulfilled[2].

Until the present, several studies have focused on bed bath materials. Some of these studies noted an increased risk of infection by cotton towels reused after cleaning and disinfection[3, 4], while others reported hospital-acquired infection by Bacillus cereus growing in towels[5], although these studies only examined the current status. We entrusted a specialized institution to culture bacteria growing on reused cotton towels, and obtained a high general bacterial count of 2,360 ±252 cfu/100 cm^2, which cannot be ignored in terms of infection prevention[6]. The results confirmed that these towels are not safe materials for bed baths, but reused cotton towels continue to be used in nursing practice settings. In Western countries, the effects of bed baths using cotton and single-use synthetic towels were compared from the perspectives of cleanliness, comfort, and cost-effectiveness, and synthetic towels were superior in all aspects[7, 8]. However, these studies simply compared healthcare professionals' impressions of bed bath effects, and the evidence remained poor. The traditional hygiene processes are also a barrier to the establishment of sufficient evidence.

Under these circumstances, we first focused on single-use synthetic towels as materials that replace cotton towels. We compared 3 types of single-use synthetic towels with markedly different surface properties and thickness levels, and found the thin, nonwoven type subjectively and physiologically superior to the others[9]. Subsequently, we conducted experiments to compare the effects of partial bed baths using cotton and synthetic towels[10]. The results supported the advantage of cotton towels in comfort, but their heat-retaining property was unsatisfactory. In contrast, synthetic towels were excellent in heat retention, but their flat surface did not create comfortable feelings. Thus, both types of towel had advantages and disadvantages due to the physical properties of their surfaces, but it was found that the most excellent types of synthetic towel have a similar bed bath effect to cotton towels. However, we could not obtain sufficient evidence regarding appropriate surface unevenness levels for synthetic towels to create comfortable feelings when used as an alternative material to cotton towels in nursing practice settings. Evidence to theorize their moisturizing and cleaning effects also remained insufficient. The results indicated the necessity of continuously examining appropriate materials and surface properties, focusing on surface unevenness, to find synthetic towels that enhance physiological and subjective comfort.

Therefore, as the first step, we compared the effects of complete bed baths using coarse and fine synthetic towels in a simulated clinical setting. Subjective evaluation revealed the superiority of the coarse to fine towels in creating comfortable feelings with a favorable texture when used as a bed bath material. The moisturizing and cleaning effects were similar between the 2 types, but the coarse towels stably retained moisture over time[11]. On the other hand, the sense of comfort was enhanced only temporarily, and it did not last until the final point in either case, revealing insufficient surface unevenness levels of both types and the urgent need to establish evidence regarding appropriate materials and surface properties of towels.

In the present study, we performed complete bed baths using coarse synthetic[11] and gauze towels with a high surface unevenness level resulting from their surface properties to compare comfort and skin cleanliness between different towel materials and surface properties.

Methods

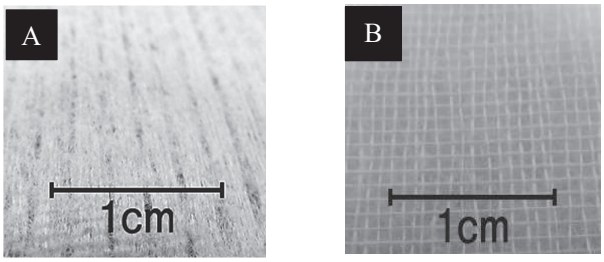
Study design: This study used a quasi-experimental design in which two types of interventions, complete bed baths using synthetic/gauze towels, were provided at random for the same participants on different days.

Participants and sample size: The sample size was set at 15 students considering the load on the participants. The difference detected by the test with the set number of cases is 5.4 and the width of the 95% confidence interval in the interval estimation is ± 3.8, when the significance level is 0.05, the power is 0.8 and the standard deviation is 6.9, which is maximum value of standard deviation of difference between gauze towels use and synthetic towels use for heart rate difference between time points in preliminary experiments.[12]. All the participants were healthy, normal build (BMI 21.5±0.9) male students (aged 21.2± 0.9) who had no skin wounds or allergies.

1) Outline and characteristics of the towels

Figure 1 outlines the towels used in this study. The synthetic towels were nonwoven fabric-type coarse towels (7 meshes/cm^2; SPC Limited Company)[11]. Their

elaborate net structure was created with a large number of filaments made from rayon and polyester fiber materials vertically and horizontally crossing each other. The gauze towels compared with synthetic towels were made by physically integrating gauze and nonfat cotton without using adhesives (100 meshes/cm^2; Ryugu Co., Ltd.).



Synthetic towel: 7mesh/ cm^2　　Gauze towel: 100mesh/ cm^2

Figure 1. Surface of towel fabric.

2) Preparation of towels for the bed baths

Towel materials: We used 2 types of towel with different surface properties (synthetic: 20×30 cm and 7 meshes/cm^2; and gauze: 20×30 cm and 100 meshes/cm^2), unifying their size, weight, and water content. The synthetic towels contained purified water and a solution with small volumes of antiseptic and disinfecting ingredients (fermentative alcohol, phenoxyethanol, methyl parahydroxybenzoate, and ethyl parahydroxybenzoate) and moisturizing, lubricating, emulsifying, and antiseptic ingredients (propylene glycol). Therefore, we treated the synthetic towels with high-temperature heat to remove all ingredients other than their raw fabric materials. They were first heated with a clothes iron and then dried in an oven at 90∞ C for 60 minutes to reduce the water content to lower than 0.1%. In addition, we confirmed that they contained no dermal irritants through outsourced testing (Falco Life Science Ltd.).

We prepared 8 sets of a triple-sheet synthetic towel of 15 g (a total of 120 g) and 8 sets of a gauze towel of 15 g (a total of 120 g) that did not contain any ingredients and were dry, for one person. A bed bath solution was applied to all towels at 150 mL, which was the maximum possible volume applicable without dripping even when the towels were grasped. Subsequently, both types of towel were folded to palm size (13×8 cm). After these processes, the 2 types of towel became equal in their size and weight, and prepared for comparison of bed bath effects based only on the surface properties. The synthetic and gauze towels were stored in a bed bath container at a constant temperature (85.7±0.1℃) to keep the former at 59.6±0.4℃ and the latter at 58.7±0.4℃.

3) Bed bath environment

We prepared 2 beds for the bed baths, and alternately used them to prevent the warmth of the last participant's body from remaining on the bed sheet until the next session. For each participant, we measured the room temperature, humidity, illumination, and noise level, which might influence the measurement data. During each bed bath, a room temperature of 24.1 ±0.1℃ and a humidity of 48.8±0.6% were maintained, with the intensity of illumination at 25.6±1.6 Lux and noise level at 46.0±0.3 dB.

4) Method of bed bath

To unify the quality of the bed bath, the same practitioner performed the procedure for all participants. The towels were folded to palm size (13×8 cm). The length and force of each wipe was approximately 23 to 25 cm and 0.57±0.04 kgf/cm^2, respectively. We conducted a preliminary experiment on the wiping pressure. A simple pressure distribution measurement system, Octosense (made by Nitta) was attached to the right forearm of 15 subjects (at 5 cm intervals above the wrist) at 3 points, and the pressure was averaged after wiping it 3 times. The practitioner initially placed the participants in the left lateral recumbent position, and applied a hot towel sheet to their back for 30 seconds. After removing that towel, she took a new one, and performed 2 sets of 5 repetitions of upward and downward wipes along the spine from the posterior region of the neck to lower back on the left and right sides. Subsequently, placing the participants in a supine position, she performed 3 repetitions of upward and downward wipes along their both arms, neck, chest, abdomen, and both legs, in this order. This unified bed bath procedure was performed for all participants. Towels were changed whenever shifting the region. The facial, genital, and gluteal areas were excluded in all cases.

2. Data collection

1) Measurement using subjective indices

To subjectively compare the texture and heat-retaining property between cotton and synthetic materials, we used a short Japanese version of the Profile of Mood States (short-version POMS-J)[13] and a visual analogue scale (VAS)[14, 15]. We examined the participants' psychological conditions before and after the bed baths using the former, and their levels of wakefulness and relaxation using the latter. POMS-J, consisting of 6

subscales: <tension-anxiety>, <depression>, <anger-hostility>, <vigor>, <fatigue>, and <confusion>, enabled us to measure rapidly changing moods and emotions before and after the bed baths. There are 30 questions to be answered on a 5-point scale (0-4 points). We used the following formula to standardize the POMS-J scores as T-scores, based on the raw scores for each question: [T-score=50+10× (raw score− mandard deviation)]. Similarly, we assessed the levels of wakefulness and relaxation using VAS. One of us presented a 100-mm horizontal line to each participant, with the descriptions of "Definitely no" (0) and "Definitely yes" (100) at the left and the right ends, respectively, traced the line with her finger, and drew a vertical line at the point indicated by the participant. Furthermore, at 30 minutes after the bed bath, we asked the participants about their impressions of the texture of each type of towel. We examined 7 aspects of texture based on the findings of a previous study[7] (Larson, Ciliberti, & Chantler, 2004): <Soft>, <Warm>, <Favorable texture>, <Feeling comfortable when being wiped>, <Feeling refreshed>, <A sense of fitness> (skin contact and thickness), and <Feeling that the body has been cleaned>. Each aspect was rated on a 3-point Likert scale from "Definitely no" (1) to "Definitely yes" (3).

2) Measurement using objective indices

To objectively compare the effects of bed baths using 2 types of towel with different surface properties, we measured the skin temperature, core temperature, heart rate, skin moisture and oil contents, skin surface pH and cleanliness levels, and blood pressure. For these measurements, we used the following devices: skin temperature: a digital clinical thermometer for continuous measurement Terumo Finer CTM-303 (Terumo Corporation); core temperature: a zero-heat-flow clinical thermometer Coretemp CM-210 (Terumo Corporation); heart rate: an electrocardiogram MemCalc/Tarawa (GMS Co., Ltd.); skin moisture content: Corneometer® CM825 (Courage + Khazaka electronic GmbH); skin oil content: Sebu-meter®SM810 (Courage + Khazaka electronic GmbH); skin surface pH level: Skin pH Meter® PH900 (Courage + Khazaka electronic GmbH); skin cleanliness level: Lumitester PD-30 (Kikkoman Biochemifa Company); and blood pressure: a digital sphygmomanometer HEM-737 Fuzzy (Omron Corporation).

We attached surface probes for skin temperature measurement to 4 regions: the anterior chest (midpoint between both papillae), right forearm (midpoint between the elbow and wrist joints), right fourth finger pulp, and hallux of the left foot. When measuring the core temperature, we covered the probe (Core Temperature Probe PD1, Terumo Corporation) with a piece of gauze folded in four to avoid direct contact between the sensor and skin, and attached it to the point right under the navel with tape with a width of 2.5 cm. We performed electrocardiography, adopting the 3-lead methods.

We measured the skin moisture and oil contents, surface pH level, and cleanliness in the left cervical region. For skin cleanliness evaluation, we measured

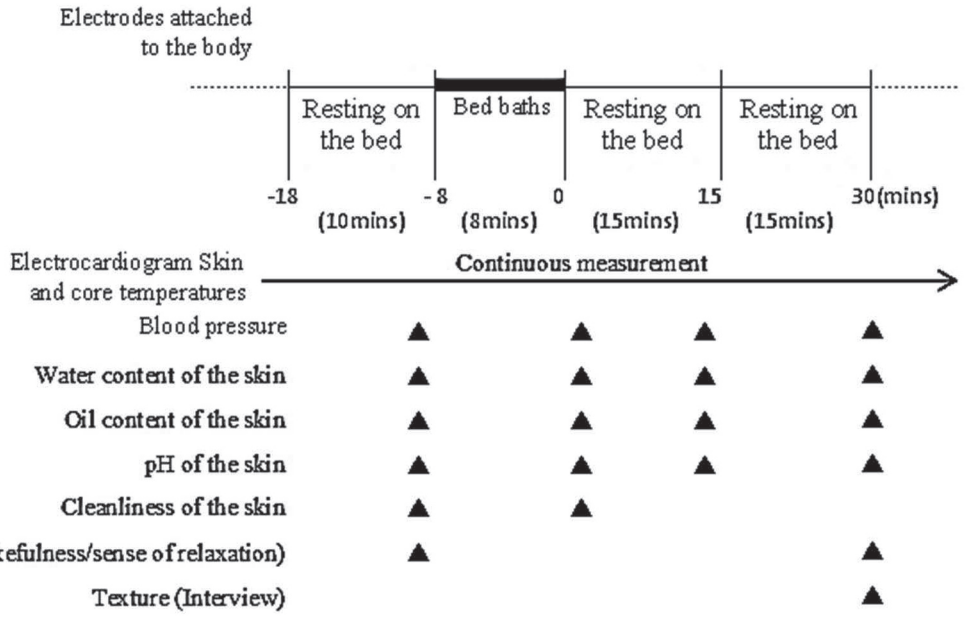


Figure 2. Experimental protocol.
▲ represents the point of measurement for each

the ATP activity level. ATP is a chemical substance that exists in all living bodies, such as animals, plants, and microorganisms. We used this index to count microorganisms such as bacteria. We chose the left cervical region for these measurements, as it does not require positioning or pulling blankets off, and consequently influences autonomic activity less. For the same reason, we examined the skin in the following order: skin moisture content, oil content, surface pH level, and cleanliness level. The site of measurement in the left cervical region was a section with a width of 40×40 mm with its center at 50 mm above a fourth of the clavicle from the sternal end. We measured the skin moisture content and surface pH level three times to adopt a mean at each point. We measured the skin oil content and cleanliness level once, and adopted a mean at each point. For each measurement of the skin moisture/oil content or surface pH level, we slightly shifted the site of measurement within the left cervical region. We measured the skin cleanliness level using a cotton swab contained in the attached cleaning kit. We moistened the cotton swab with sterile distilled water, and rubbed the skin surface forwards and backwards 5 times with it.

We collected data, as shown in Figure 2. First, we continuously recorded the skin temperature, core temperature, and electrocardiographic value for 50 minutes from the initiation of bed rest to another rest after the bed bath. Among these values, we adopted those obtained at 4 points for the skin and core temperatures: immediately before the bed bath, immediately before the completion of the bed bath, and 15 and 30 minutes after the bed bath. For the left brachial artery blood pressure, skin moisture and oil contents, and skin surface pH level, we adopted the values obtained at the following 4 points: immediately before, immediately after, and 15 and 30 minutes after the bed bath. Lastly, for the skin cleanliness level, we adopted the values obtained at 2 points: immediately before and immediately after the bed bath.

3. Procedures

We instructed the participants to stop eating and drinking 2 hours before the initiation of the experiment. Prior to the experiment, the participants changed into a patient gown and short pants over their underwear in a dressing room, and moved with slippers on their feet. Subsequently, in another room, we provided them

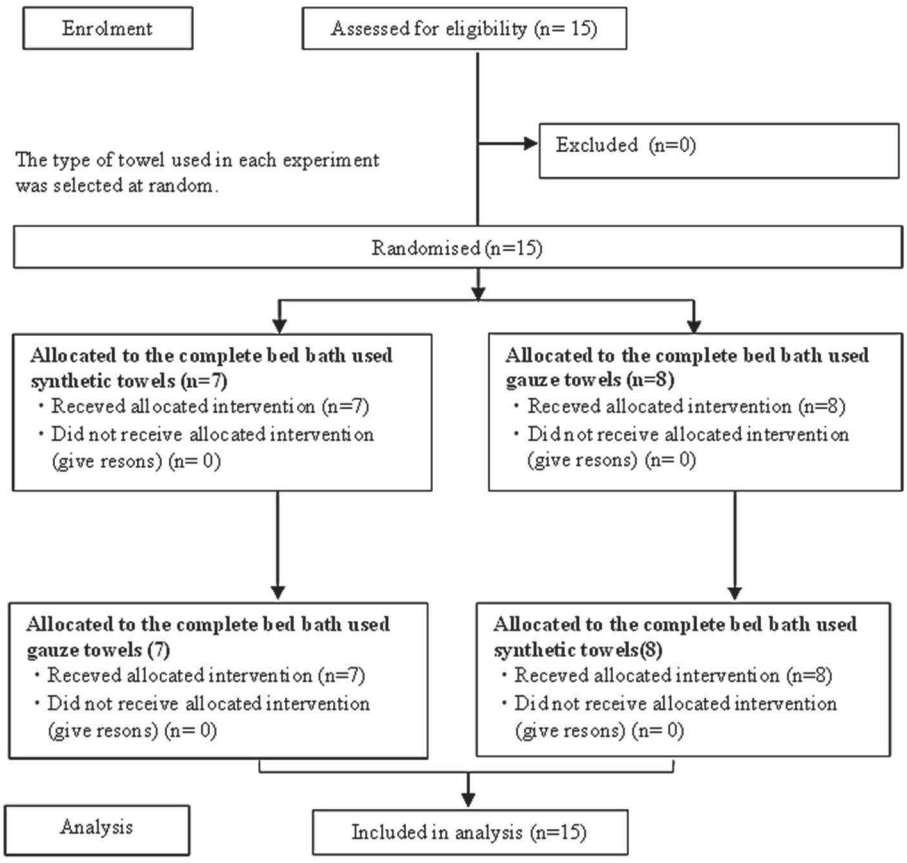


Figure 3. Design of the study.

with an outline of the experiment, and confirmed their current health condition.

We guided each participant to a private room for the bed baths, and instructed him to lie on the bed. We covered him from his toes to shoulders with 2 blankets, and pulled the hems of his short pants up to his upper thigh. We attached probes for the core and skin temperature measurements and electrodes for the electrocardiography to his body.

We conducted the experiment, as shown in Figure 2. After a 12-minute bed rest period with probes attached, the practitioner performed the bed bath procedure for 8 minutes. After the bed bath, a 30-minute bed rest period was inserted. Thus, the duration of the entire process was 50 minutes. During the initial bed rest period, we conducted evaluation using the short-version POMS-J and VAS (wakefulness/relaxation). Immediately before the bed bath, we measured the blood pressure, skin moisture and oil contents, and skin surface pH and cleanliness levels. The participants closed their eyes during the bed baths. We measured the blood pressure, skin moisture and oil contents, and skin surface pH level immediately after and 15 and 30 minutes after the bed bath, and the skin cleanliness level immediately after the bed bath. At 30 minutes after the bed bath, we conducted evaluation using the POMS-J and VAS (wakefulness/relaxation) again, and examined the participants' impressions of the texture of each type of towel. We continuously measured the electrocardiographic value and core and skin temperatures throughout the experiment.

Verbal communication with the participants during the experiment was limited to the following occasions: immediately before pulling the blanket off, immediately before covering their body with a towel, when confirming the temperature of the towel, and immediately before each measurement.

All the participants participated in the experiment twice; they received a bed bath during the same time zone (9:00 to 16:00) on 2 different days when the synthetic and gauze towels were used, respectively. The order in which the 2 types of towel were used for the 2 sessions was determined at random (Figure 3).

6. Data analysis

We analyzed all the data collected using the statistical software SPSS Ver. 24.0 for Windows. We calculated the autonomic activity level by analyzing the electrocardiographic data, adopting the maximum entropy method (MemCalc/Tarawa, GMS Co., Ltd.). Through frequency analysis, we set the low (LF) and high (HF) frequency components of heart rate variability at 0.04-0.15 and 0.15-0.40 Hz, respectively, and regarded the LF/HF ratio and HF as representing sympathetic and parasympathetic activities, respectively. Additionally, we analyzed the data representing the heart rate (HR) and parasympathetic (HF) and sympathetic (LF/HF) activities during each of the following stable 2-minute-periods: before the bed bath (from 3 minutes after the initiation of rest), immediately before the completion of the bed bath (from 6 minutes after the initiation of the bed bath), 15 minutes after the bed bath (from 11 minutes after the bed bath), and 30 minutes after the bed bath (from 23 minutes after the bed bath). We chronologically compared the data obtained immediately before, 15 minutes after, and 30 minutes after the bed bath with those obtained before it as baseline values. At the same time, we compared the amounts of change in each value at each point when using the synthetic and gauze towels. The heart rate varied between the 2 types of towel at 15 minutes after the bed bath, but the difference was slight. Therefore, we used the values before the bed bath as baseline values (0) to compare the amount of change between them.

Similarly, we examined chronological changes in the core and skin temperatures immediately before and 15 and 30 minutes after the bed bath, with those before the bed bath as baseline values. In both cases, we compared the amount of change at each point between the 2 types of towel. We also examined chronological changes in the skin moisture/oil contents and surface pH level immediately before, immediately after, and 15 and 30 minutes after the bed bath, with those before the bed bath as baseline values, and compared the amount of change in each index at each point between the 2 types of towel. As for ATP activity as an index of skin cleanliness, we calculated the change rate immediately after the bed bath, with the values before the bed bath as baseline values (0) for comparison. We also compared moods before and after the bed bath based on the POMS-J and VAS scores, and examined the impression of texture of each type of towel after the bed bath. For statistical analysis, we used the non-parametric test. For intra-group comparison of measurement values, we conducted the Friedman test, and for inter-group comparison using the amounts of change based on the values during the rest period before the bed bath, we used the Wilcoxon signed-rank test. To compare the impression of texture after the bed bath between the 2 types of towel, we conducted the chi-square test. In all cases, we set the significance level at lower than 5%.

Ethical considerations

We provided all the participants with an explanation of the purpose of the study, guarantee of free decision-making, protection of privacy, preservation of confidentiality, publication of the results, and a guarantee of withdrawal at any time with no disadvantage to obtain their signed informed consent. The study was conducted with the approval of the Research Ethics Committee of the affiliated institution, and there were no conflicts of interest to declare.

Results

To compare the effects, we performed complete bed baths (excluding the facial and genital areas) on 15 healthy male students through a unified procedure using 2 types of towel differing only in the surface properties. Originally, repeated measures ANOVA should be performed, but since the purpose of this study is exploratory, we used the Wilcoxon signed-rank test.

1. Comparison of the bed bath effects based on the subjective indices

On comparing the participants' impressions of textures of the synthetic and gauze towels, the rate of answering "Definitely yes" was lower than 30% for all items in both cases. For 6 out of the 7 items, <Warm>, <Favorable texture>, <Feeling comfortable when being wiped>, <Feeling refreshed>, <A sense of fitness>, and <Feeling that dirt has been removed>, 50 to 90% answered <Neutral>. The only item, for which the synthetic towels were rated significantly higher than the gauze towels, was <Soft> (P=0.001) (Table 1). Comparison of the participants' VAS scores, representing their levels of wakefulness and relaxation before and after the bed baths using the synthetic and gauze towels, revealed that the level of relaxation

Table 1. Texture of the materials of towels.

Item	Responses	Synthetic towel	Gauze towel	χ^2
		n=15	n=15	
Soft	Yes	3	0	
	Neutral	11	4	14.6
	No	1	11	**
Warm	Yes	4	4	
	Neutral	11	10	1.1
	No	0	1	n.s
Favorable texture	Yes	4	0	
	Neutral	10	11	5.9
	No	1	4	n.s
Feeling comfortable when being wiped	Yes	2	0	
	Neutral	12	11	3.8
	No	1	4	n.s
Feeling refreshed	Yes	4	1	
	Neutral	9	13	2.9
	No	2	1	n.s
Feeling a sense of fitness	Yes	0	2	
	Neutral	13	8	4.5
	No	2	5	n.s
Feeling that the body has been cleaned	Yes	1	4	
	Neutral	13	11	3.0
	No	1	0	n.s

Note 1) χ^2 test.　** $P<.01$
Note 2) The results of inter-group comparisons were not significant.

significantly increased after the bed bath in both cases (P=0.001 in both cases). There was also a significant increase in the level of wakefulness after the bed bath using the synthetic towels (P=0.002) (Table 2).

Similarly, on comparing the participants' POMS-J scores representing their moods before and after the bed baths using the synthetic and gauze towels, there were no items with significant pre-post changes in either case, but there were decreases in the scores for <tension-anxiety>, <depression>, and <vigor>, and <fatigue>. When using the synthetic towels, the score for <anger-hostility> increased, whereas that for <confusion> decreased. In contrast, when using the gauze towels, the score for <tension-anxiety> decreased, whereas that for <confusion> increased (data not shown).

2. Comparison of the bed bath effects based on the objective indices

To clarify the effects of complete bed baths using 2 types of towel (synthetic/gauze) with different surface properties on the human body, we examined the results of analysis based on each physiological index. Table 3 shows the core and skin temperatures, Table 4 shows the blood pressure as a hemodynamic index, Table 5 shows the heart rate and autonomic activity, and Table 6 shows the skin moisture/oil contents and surface pH level.

Both when using the synthetic and gauze towels, there was a marked increase of approximately 0.9℃ (P=0.001) in the core temperature from immediately before to 30 minutes after the bed bath (Table 3). The skin temperatures of the anterior chest (approximately 1.0℃) (P=0.001) and the right forearm (approximately 0.4℃) (P=0.001) also markedly increased. Furthermore, in both cases, the skin temperature of the tip of the hallux of the left foot (approximately 0.9℃) and that of the fourth finger pulp of the right hand (approximately 0.8℃) (P=0.002) significantly decreased from immediately before to during the bed bath, and recovered to the pre-interventional values at the final point. The skin temperature of the anterior chest at 15 minutes after the bed bath was the only item that revealed a greater increase in the value with the gauze (1.0℃) (P=0.001) compared with synthetic (0.7℃) towels.

When focusing on the blood pressure levels when receiving complete bed baths using the 2 types of towel (Table 4), significant decreases in the systolic (approximately -5.2 mmHg) (P=0.007) and diastolic (approximately -4.3 mmHg) (P=0.018) blood pressure levels were observed at 15 minutes after the bed bath using the synthetic towels, and the values tended to continue to decrease until the final point. In the case of the gauze towels, the systolic blood pressure level increased (approximately 0.8 mmHg) immediately after the bed bath, decreased (approximately -1.7

Table 2. Changes in VAS for wakefulness and the sense of relaxation following bed.

Item	Materials	Mean(SE)	
		Before bed baths	After bad baths
Wakefilness	Synthetic towels (n=15)	62.1 (5.1)	43.9 (6.0) **
	Gauze towels (n=15)	57.9 (4.9)	55.5 (4.6)
Sense of erlaxation	Synthetic towels (n=15)	70.0 (3.9)	81.1 (2.8) **
	Gauze towels (n=15)	66.1 (4.8)	73.5 (5.6) **

Note) Wilcoxon signed-rank tests were used to compare values prior to and following the intervention. ** $P<.01$

Table 3. Changes in core and skin temperatures after bed baths using synthetic and gauze towels.

Item	Materials	Mean (SE)			
		Before use	Immediately after use	15 minutes after the completion	30 minutes after the completion
Core temperature	Synthetic towels (n=15)	35.2 (0.2)	35.7 (0.2)	36.0 (0.1)	36.1 (0.1)
	Gauze towels (n=15)	35.4 (0.3)	35.8 (0.2)	36.1 (0.1)	36.2 (0.1)
Anterior chest	Synthetic towels (n=15)	35.4 (0.2)	34.5 (0.2)	34.9 (0.2)	35.2 (0.2)
	Gauze towels (n=15)	34.0 (0.2)	34.6 (0.2)	35.0 (0.2)	35.2 (0.1)
Right arm	Synthetic towels (n=15)	34.4 (0.1)	34.3 (0.1)	34.7 (0.1)	34.8 (0.1)
	Gauze towels (n=15)	34.6 (0.1)	34.5 (0.1)	35.0 (0.1)	35.0 (0.1)
4th finger pulp of the right hand	Synthetic towels (n=15)	35.4 (0.1)	34.4 (0.4)	35.2 (0.2)	35.2 (0.2)
	Gauze towels (n=15)	35.6 (0.1)	34.8 (0.3)	35.5 (0.1)	35.5 (0.1)
1st toe of the left foot	Synthetic towels (n=15)	33.0 (0.5)	32.2 (0.5)	32.5 (0.6)	33.1 (0.5)
	Gauze towels (n=15)	32.8 (0.6)	31.6 (0.8)	32.6 (0.6)	32.8 (0.5)

Note 1) Following Friedman's test, values obtained before and after the intervention were compared using the Wilcoxon signed-rank test.　* P <.05, ** P <.01

Note 2) To compare the amount of change in the measurement time of synthetic and gauze towels, Wilcoxon's signed rank test was used.　†† P <.01.

mmHg) after 15 minutes, and recovered to the pre-interventional value at the final point, whereas the diastolic blood pressure level significantly increased (4.2 mmHg) (P=0.011) immediately after the bed bath, and remained high (approximately 2.8 mmHg) until the final point. On comparing the amount of change at each measurement point between the 2 types of towel, the increases in the diastolic blood pressure level (approximately 4.2 mmHg) (P=0.013) immediately after the bed bath and in the systolic (approximately 4.3 mmHg) (P=0.029) and diastolic (approximately 2.0 mmHg) (P=0.002) blood pressure levels at 15 minutes after the bed bath were more significant when using the gauze towels.

Variability analysis using the electrocardiographic records (Table 5) revealed a tendency for the heart rate to decrease (approximately -3.6 bpm) from immediately before the completion of the bed bath to the final point when using the synthetic towels, although the difference was non-significant. When using the gauze towels, the heart rate continued to decrease (approximately -4.5 bpm) from immediately before the

Table4. Change in blood pressure after bed baths using synthetic and gauze towels.

Materials	Blood pressure (mmHg)	Mean (SE)			
		Before use	Immediately after use	15 minutes after the completion	30 minutes after the completion
Synthetic towels (n=15)	SBP	116.1 (2.5)	114.8 (2.8)	110.9 (2.9)	113.6 (3.0)
	DBP	68.1 (1.5)	67.5 (1.8)	63.8 (1.7)	67.6 (2.3)
Gauze towels (n=15)	SBP	116.7 (2.6)	117.5 (2.2)	115.0 (2.6)	116.7 (2.8)
	DBP	66.3 (1.5)	70.5 (2.1)	68.3 (2.1)	69.8 (1.9)

Note 1) Following Friedman's test, values obtained before and after the intervention were compared using the Wilcoxon signed-rank test. * P <.05, ** P <.01

Note 2) To compare the amount of change in the measurement time of synthetic and gauze towels, Wilcoxon's signed rank test was used. † P <.05, †† P <.01

Table5. Changes in HR, HF and LF/HF after bed baths using synthetic and gauze towels.

Item	Materials	Mean (SE)			
		Before use	Immediately after use	15 minutes after the completion	30 minutes after the completion
HR (bpm)	Synthetic towels (n=15)	64.7 (2.2)	61.9 (2.0)	60.4 (2.1)	61 (2.5)
	Gauze towels (n=15)	64.0 (1.7)	60.8 (2.2)	59.1 (2.3)	58.5 (2.5)
HF ($msec^2$)	Synthetic towels (n=15)	738.1 (336.3)	975.3 (320.2)	781.7 (230.3)	570.9 (175.8)
	Gauze towels (n=15)	579.4 (162.3)	796.3 (217.7)	1118.6 (221.5)	962.3 (216.8)
LF/HF	Synthetic towels (n=15)	2.6 (0.6)	1.9 (0.6)	1.5 (0.2)	2.6 (0.8)
	Gauze towels (n=15)	2.9 (1.0)	2.4 (0.4)	3.3 (1.5)	2.0 (0.8)

Note 1) Following Friedman's test, values obtained before and after the intervention were compared using the Wilcoxon signed-rank test. * P <.05, ** P <.01

Note 2) To compare the amount of change in the measurement time of synthetic and gauze towels, Wilcoxon's signed rank test was used. † P <.05

Table6. Change in skin moisture content, oil content, pH after bed baths using synthetic and gauze towels.

Item	Materials	Mean (SE)			
		Before use	Immediately after use	15 minutes after the completion	30 minutes after the completion
Skin moisture content (%)	Synthetic towels (n=15)	61.8 (3.1)	67.3 (1.8)	58.6 (2.2)	56.7 (2.3)
	Gauze towels (n=15)	63.8 (4.0)	63.1 (2.8)	52.5 (2.1)	50.4 (2.2)
Oil content (μg/cm^2)	Synthetic towels (n=15)	12.1 (3.7)	4.1 (2.1)	1.2 (0.3)	1.5 (0.4)
	Gauze towels (n=15)	7.7 (1.5)	2.6 (0.8)	1.6 (0.4)	1.9 (0.3)
pH	Synthetic towels (n=15)	4.5 (0.1)	4.7 (0.1)	4.8 (0.1)	4.8 (0.1)
	Gauze towels (n=15)	4.5 (0.1)	4.6 (0.1)	4.6 (0.1)	4.6 (0.1)

Note 1) Following Friedman's test, values obtained before and after the intervention were compared using the Wilcoxon signed-rank test.　* P <.05, ** P <.01

Note 2) To compare the amount of change in the measurement time of synthetic and gauze towels, Wilcoxon's signed rank test was used.　† P <.05

completion of the bed bath to the final point, revealing significant differences at 15 (approximately -4.9 bpm) (P=0.028) and 30 (approximately -5.5 bpm) (P=0.004) minutes after the bed bath (P<.01 in both cases). As for the parasympathetic activity level (HF) when using the synthetic towels, it first increased immediately before the completion of the bed bath, and then decreased until the final point. In contrast, when using the gauze towels, HF continuously increased from immediately before the completion of the bed bath, and the increase was significant after 15 minutes (P=0.018). Although it slightly decreased at the final point, it remained high. The sympathetic activity level (LF/HF) decreased from immediately before to 15 minutes after the bed bath, and recovered to the pre-interventional value at the final point when using the synthetic towels, whereas it decreased immediately before the completion of the bed bath, increased after 15 minutes, and decreased again at the final point when using the gauze towels. On comparing the amount of change at each measurement point between the 2 types of towel, the increase in the parasympathetic activity level (HF) at 15 minutes after the bed bath was more significant when using the gauze towels (P=0.012) .

Table 6 shows the skin moisture/oil contents and surface pH levels. When using the synthetic towels, the skin moisture content increased (approximately 5.5%) immediately after the bed bath, and slightly decreased (approximately -4.2%) until the final point. When using the gauze towels, the skin moisture content slightly decreased (approximately -0.7%) immediately after the bed bath, and the decreases at 15 (approximately -11.3%) (P=0.007) and 30 (approximately -13.4%) (P=0.001) minutes after the bed bath were significant. On comparing the amount of change at each measurement point between the 2 types of towel, the decreases in the skin moisture content at 15 (approximately -11.3% vs. 3.2%) (P=0.017) and 30 (approximately -13.4% vs. -5.1%) (P=0.015) minutes after the bed bath were more significant when using the gauze towels. On the other hand, when using the synthetic towels, there were significant decreases in the skin oil content at 15 (approximately -10.9 μg/cm^2) (P=0.001) and 30 (approximately -10.6 μg/cm^2) (P=0.005) minutes after the bed bath. When using the gauze towels, there were significant decreases in the skin oil content immediately before (approximately -5.1 μg/cm^2) (P=0.011), 15 minutes after (approximately -6.1 μg/cm^2) (P=0.001),

and 30 minutes after (approximately -5.8 $\mu g/cm^2$) (P=0.004) the bed bath. In addition, when using the synthetic towels, the skin surface pH level significantly increased (approximately 0.2) (P=0.035) immediately before the completion of the bed bath, and a certain level was maintained until the final point (P=0.018). When using the gauze towels, the skin surface pH level increased (approximately 0.1) immediately before the completion of the bed bath, and remained high until the final point. The rate of change in the skin cleanliness level between before and after the bed bath was 18.5% for the synthetic towels and 43.1% for the gauze towels, revealing a significant difference(P=0.001) (data not shown).

Discussion

This study compared the effects of complete bed baths using 2 types of towel (synthetic/gauze) with different surface properties on the human body, involving healthy male students, and clarified the relationship between the surface unevenness of towels and the effects of complete bed baths. This section discusses the results regarding texture (comfort), heat-retaining effects, moisturizing effects, and skin cleanliness.

1. Comparison of texture based on surface unevenness

In our previous studies, we focused on the surface unevenness of synthetic towels used as an alternative material to cotton towels in nursing practice settings to determine the appropriate materials and surface properties, and demonstrated that tactile/pressure stimulation to the skin produced by these towels activates parasympathetic nerves (HF), and suppresses sympathetic nerves (LF/HF)[9), 10)].

Among the results of subjective assessment in the present study, the increased level of relaxation after the bed bath achieved with both types of towel should be particularly noted, although there were no marked changes in the short-version POMS-J scores in either case. When focusing on texture, a stronger <Soft> feel was achieved, the level of wakefulness decreased after the bed bath, and the systolic and diastolic blood pressure levels decreased at 15 minutes after the bed bath using the synthetic towels. However, after the bed bath, more than 90% of the participants negatively evaluated this type of towel in all aspects of texture excluding softness, and another type, gauze towels, in all aspects. This suggests that the synthetic towels with 7 meshes/cm2 on their surface, a lower level of surface unevenness, were felt <Soft>, as they provided milder tactile and pressure stimulation, but they did not provide comfort in other aspects. In contrast, the gauze towels with 100 meshes/cm^2 may have produced excessive tactile and pressure stimulation, resulting in a rough texture and lack of comfort.

Among the objective indices, there was little change in the heart rate (HR) and parasympathetic activity level (HF), representing autonomic nervous system functions, when using the synthetic towels. This indicates that the comfortable feeling created by their texture did not last until 30 minutes after the bed bath, and is consistent with the results of a previous study, in which synthetic towels did not provide sufficient tactile and pressure stimulation[11)]. The gauze towels led to a decrease in heart rate from 15 minutes after the bed bath to the final point and increase in the parasympathetic activity level (HF) at 15 minutes after the bed bath as clear responses to tactile and pressure stimulation to the skin. This is consistent with the results of other previous studies[16), 17)], which were also attributed to the larger number of meshes on the surface of gauze towels compared with synthetic towels. Thus, the former may have created stronger stimulation to be perceived by tactile/pressure receptors in tissues, such as the skin and muscles, and conveyed to the cerebral cortex through nerves. However, it is likely that the stimulation was too strong, as the diastolic blood pressure level increased immediately after the bed bath, the sympathetic activity level (LF/HF) increased at 15 minutes after the bed bath, and there were no favorable results of subjective evaluation, except for the level of relaxation which increased immediately after the bed bath.

On analyzing the core and skin temperatures based on these findings, the skin temperature may drop due to heat of vaporization immediately after the end of the whole-body cleansing.

Then, it seems that the evaporation immediately after the whole-body cleansing ends and returns to the original state[19)]. The 2 types of towel were shown to have a similar heat-retaining effect, as the core body temperature and skin temperature, excluding that in peripheral regions, increased from during the bed bath to the final point, while the peripheral skin temperature decreased at 15 minutes after the bed bath in both cases. The synthetic towels used in the present study had an elaborate net structure with a large number of filaments made from rayon and polyester fiber materials vertically and horizontally crossing each other, while the gauze towels were made by physically integrating

gauze with 100 meshes/ cm^2 and nonfat cotton without using adhesives. Given these characteristics, the rate of heat loss from the interfilament spaces may have been low in both cases. Indeed, the peripheral skin temperature decreased at 15 minutes after the bed bath, but gradually recovered, and the heat-retaining effect lasted until the final point. In the peripheral regions (the tips of the fourth finger pulp of the right hand and the hallux of the left foot) during a bed bath using hot towels, the peripheral blood vessels contracted, and the skin blood flow decreased, leading to a sudden decrease in the skin temperature. Then, warm blood in the surface layer of the skin returned to the trunk, increasing the peripheral skin blood flow[18),19)] and dilating the peripheral blood vessels. As a result, the skin temperature of the tips of the fourth finger pulp of the right hand and that of the hallux of the left foot gradually increased until the final point.

In short, the synthetic towels were rated as soft in the subjective evaluation of texture, but they led to little change in autonomic activity due to insufficient tactile and pressure stimulation. The gauze towels were not rated as comfortable in any aspect of texture, except for the level of relaxation, but their uneven surface produced a strong tactile and pressure stimulation, and led to favorable changes in the autonomic activity.

2. Comparison of moisturizing effects based on surface unevenness

The skin consists of 3 layers: the epidermis that is the outermost layer, dermis, and subcutaneous. The most superficial layer of the epidermis is the stratum corneum, followed by the stratum granulosum, stratum spinosum, and stratum basale. Sebum in the stratum corneum functions as a barrier on the skin to prevent the evaporation of accumulated moisture[20)].

On comparing the moisture content of the skin surface between the synthetic and gauze towels in the present study, a high skin moisture content was maintained from during the bed bath to the final point in the former, whereas there was a marked decrease in the value from 15 minutes after the bed bath to the final point in the latter. When using the synthetic towels with 7 meshes/cm^2 on the surface, their elaborate net structure made of cut rayon and polyester fiber materials created a larger skin contact area during the bed bath. In such an area, adsorption of water to the surface of the skin caused the stratum corneum to swell, while increasing the skin moisture content, and this may have resulted in a greater moisturizing effect. When using the gauze towels made by physically integrating gauze with 100 meshes/cm^2 and nonfat cotton, a larger number of interfilament spaces in the skin contact area allowed significant evaporation of water from the surface of the skin, but water may have been absorbed by the absorbent cotton wool integrated with the gauze. Thus, it is also possible that the skin surface lacked moisture due to the removal of sebum, natural moisturizers in the epidermis, and even intercellular lipids in the corneum[20)].

In general, sebaceous glands secreting sebum are concentrated in the face and scalp, chest, back, and neck[21)]. With fatty acids and lactate in sweat covering the skin surface, normal skin pH levels are maintained on the slightly acidic side, at 4.2-6.4, and increased pH levels negatively affect the skin barrier function[22)]. Furthermore, in the case of dry skin, the skin surface pH level gradually increases due to poor control of water vapor loss from the inside, making the skin tend to be dry[23)]. On comparing the skin surface oil content and pH level between the synthetic and gauze towels, with these findings taken into account, the decrease in the skin oil content was marked from immediately before the completion of the bed bath to the final point in both cases. However, when using the synthetic towels, the skin moisture content gradually decreased after the bed bath, the skin cleanliness level was relatively low (18.5%), and the skin surface pH level continued to increase from immediately before the completion of the bed bath to the final point, but a mildly acidic condition was maintained. In contrast, when using the gauze towels, the skin moisture content significantly decreased until the final point, the skin cleanliness level was relatively high (43.1%), and the skin surface pH level was appropriate to maintain a mildly acidic condition until the final point. Thus, the results did not reveal marked differences between the 2 types of towel in the moisturizing effects, covering the skin moisture content and skin surface pH level. However, when using the gauze towels, a greater effect of removing dirt from the skin was achieved, and the material itself was able to retain moisture suggesting that the skin barrier function was maintained in a normal state in this case.

In summary, the synthetic towels were highly moisturizing, but their effect of removing dirt from the skin was poor, whereas the gauze towels excessively removed moisture from the skin, but they were effective to remove dirt from it.

Conclusion

In this study, we compared the effects of complete bed baths using synthetic and gauze towels in a simulated clinical setting. The synthetic towels were found to be highly moisturizing, and their soft texture was highly rated in the subjective evaluation, but their effect of removing dirt from the skin was poor, and they led to little change in the autonomic activity due to insufficient tactile and pressure stimulation. The gauze towels were not rated as comfortable in the subjective evaluation, but they provided stronger tactile and pressure stimulation, which led to favorable changes in the autonomic activity, and effectively removed dirt from the skin. Thus, although both types of towel had advantages and disadvantages due to the physical properties of their surfaces, the results revealed that they are not physiologically or subjectively comfortable materials yet. As future perspectives, we will continue to focus on the surfaces of towels, specifically their surface unevenness, and examine appropriate materials and surface properties to enhance physiological/subjective comfort.

Acknowledgments

We would like to express our deep gratitude to all those who understood the study objective, and provided cooperation and advice. This study was supported by a Grant-in-Aid for Scientific Research FY2015 (grant number: 15K15808).

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香川県立保健医療大学雑誌　第14巻，1 －16，2023

タオルの生地表面の形状の違いが及ぼす全身清拭効果
－化繊タオルとガーゼタオルの比較－

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要旨

目的：タオルの生地表面の形状（メッシュ）の違い（粗い目の化繊タオル，ガーゼタオル）が全身清拭効果に及ぼす影響を比較検討する．

方法：同意の得られた健康な男子学生 15 名を対象に，異なる日にタオルの種類を変えて全身清拭を行った．清拭効果の評価指標には深部温，皮膚温，血圧，心拍変動，皮膚の水分量･油分量･pH, 清浄度, POMS-J 短縮版, 覚醒度とリラックス度, 肌触りのリッカートスケールを用いた．

結果：両者ともに清拭終了後のリラックス度の増加（P=0.001），最終まで深部温と末梢以外の皮膚温の上昇，終了後の油分量が低下した（それぞれ P=0.001）．化繊タオルでは終了後の柔らかい肌触り感（P=0.001）と覚醒度の低下（P=0.002），終了 15 分後の最高・最低血圧の低下（P=0.011）終了後の水分量の低下（P=0.001）と pH が上昇した（P=0.018）．ガーゼタオルでは終了後のリラックス度の増大以外は主観的評価で心地よい結果が得られず，終了直後の最低血圧の上昇（P=0.002），最終まで心拍数の低下（P=0.028），終了 15 分後の副交感神経活性（HF）の上昇（P=0.012），最終まで水分量が低下（P=0.001）終了後の皮膚の清浄度で汚れが落ちていた（P=0.011）．

結論：ガーゼタオルのほうが化繊タオルに比べ，生地表面の触・圧刺激が高く主観的評価を支持する結果が得られなかったが，皮膚の汚れを除去する効果があった．

Key Words：化繊タオル，ガーゼタオル，生地表面の形状の違い，全身清拭効果

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