Comparison of Effects of Complete Bed Baths Using Synthetic Towels with Different Surface Coarseness Levels

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Abstract

Objective : To compare the effects of complete bed baths using synthetic towels with different surface coarseness levels (coarse/fine).

Methods : Fifteen healthy male students were given complete bed baths using 2 types of towels on different days. Bed-bathing effects were evaluated based on core temperature, skin temperature, blood pressure, heart rate (HR) variability, skin moisture and oil contents, skin surface pH and cleanliness levels, scores from the short－version Profile of Mood States in Japanese (POMS-J), senses of wakefulness and relaxation, and the results of texture evaluations using the Likert scale.

Results : Skin moisture content and skin surface pH levels increased with a decrease in skin oil content immediately after the completion of bed bathing in both cases (P <.05) ; however, the maintenance of these indices until the final measurement point was slightly better when coarse towels were used, with a favorable impression of their texture and reduced POMS-J scores immediately after the completion of bed bathing as well as a decrease in HR and increase in parasympathetic activity levels being continuously observed until 15 minutes after (P <.05). When using fine towels, the impression of their texture was not as favorable, and reduced HR, increased parasympathetic activity levels, and decreased sympathetic activity levels were only observed 15 minutes after the completion of bed bathing (P <.05).

Conclusion : Subjective evaluations revealed the superiority of coarse to fine towels for creating a comfortable feeling with a favorable texture.The moisture-retaining property of coarse towels was also superior to that of fine towels.

Key Words : synthetic towels, different surface coarseness levels, coarse, fine, effects of complete bed baths

Introduction

In Japan, complete bed baths are a part of nursing practices for patients with severe conditions. Due to its heat-retaining, sedative, and analgesic effects, bed bathing is an established specialized procedure performed by nurses who accurately recognize patients' pathological conditions.However, new treatment and examination methods are being adopted with the progression of advanced medical technologies, and, as a consequence, nurses are now under increased pressure in medical environments. The simplification of care procedures makes it difficult to ensure a sufficient quality of care ; we previously reported patients' dissatisfaction with care services in an interview-based study[1]. Our nationwide survey involving nurses[2] also revealed that each inpatient was given a bed bath with only a few steamed cotton towels, and also that nurses cannot achieve a sense of accomplishment.

Previous studies examined the effects of complete bed baths with a focus on towel materials. Some researchers noted an increased risk of infection when cotton towels

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were reused after cleaning and disinfection[3),4)]. while others reported hospital-acquired infections caused by *Bacillus cereus* growing in towels[5)] ; however, these studies only examined the current status of patients. We entrusted a specialized institution to culture bacteria growing in reused cotton towels, and obtained a high general bacterial count of 2,360 ± 252 cfu/100 ㎠, which cannot be ignored in terms of infection prevention[6)]. These findings confirmed that although reused towels are not safe materials for complete bed baths, they are still being used in actual nursing settings. In Western countries, the effects of complete bed baths using cotton and single-use synthetic towels were compared with respect to cleanliness, comfort, and cost-effectiveness, and synthetic towels were superior in all aspects[7),8)]. However, these studies only compared medical professionals' opinions on bed -bathing effects and did not obtain sufficient evidence. Traditional hygiene processes are also a barrier to the establishment of sufficient evidence.

Therefore, we initially focused on single-use synthetic towels as materials to replace cotton towels. We compared 3 types of single-use synthetic towels with markedly different profiles and thickness levels, and found the thin, non-woven type to be subjectively and physiologically superior to the others tested[9)]. We then conducted experiments to compare the effects of partial and bed baths using synthetic and cotton towels[10)]. The findings obtained supported the advantage of cotton towels for comfort ; however, their heat-retaining property was unsatisfactory. In contrast, synthetic towels showed excellent heat retention, whereas their flat surface did not create a comfortable feeling. Thus, both types of towels had advantages and disadvantages based on their physical profiles. The best type of synthetic towel was shown to exert similar bed-bathing effects to cotton towels.

We also experimentally compared the effects of complete bed baths using synthetic towels with flat surfaces and various types of towels with higher surface coarseness levels (looped cotton towels and non-woven mesh fabrics with a coarse surface), with a focus on comfort. Towels with higher surface coarseness levels provided the skin with a pleasant tactile/pressure stimulation, and consequently suppressed the sympathetic nervous system, demonstrating that these towels positively influenced autonomic activity[9),10)]. However, we were unable to obtain sufficient evidence to establish appropriate surface coarseness levels for synthetic towels in order to create a comfortable feeling in complete bed baths using them as part of nursing practices. Their moisturizing and cleaning effects also remain unclear.

Therefore, in the present study, we examined the effects of complete bed baths using synthetic towels with different surface coarseness levels (coarse/fine) in a realistic setting by wiping entire bodies to compare comfort, moisture retention, and cleanliness.

Methods

Study design : A quasi-experimental study to compare the effects of complete bed baths performed using coarse/fine towels on the same participants on 2 randomly selected different days.

Participants : To select the number of participants, we set the significance level for testing at 0.05% and the one-tailed probability of overlooking significant differences at 0.2% based on our previous report[10)]. We then calculated standard deviations for heart rate (HR), and selected 13 subjects who showed the greatest standard deviation among all measurement values. By adding 2 subjects, 15 subjects were enrolled[11)]. All participants were male students (age : 20.2 ± 0.9) with standard somatotypes (BMI : 21.3 ± 0.6) and no health issues, skin wounds, or allergies. Our study focused on male subjects because we thought male were less ashamed of skin exposure than female.

1.Experiment

1) Towel characteristics

The coarse and fine towels used in the present study were both non-woven fabric-type thin towel sheets (SPC Limited Company), which have been reported to have a favorable heat-retaining property and texture[10)]. Their elaborate net structures are created with a large number of filaments made from rayon and polyester fiber materials vertically and horizontally crossing each other. We treated/did not treat the towels with a mixed solution that contained trace amounts of fermentative alcohol, phenoxyethanol, methyl parahydroxybenzoate, and ethyl parahydroxybenzoate as antiseptic and disinfecting components, and propylene glycol as a moisturizing, lubricating, emulsifying, and antiseptic component, in addition to purified water (bed-bathing solution).These components have been approved based on the Pharmaceuticals and Medical Devices Act to ensure the quality, effectiveness, and safety of pharmaceuticals and medical devices, and are not considered to cause allergic dermatitis or disorders. Their boiling points are as follows : propylene glycol : 188.2℃, ethanol : 78.4℃, and phenoxyethanol : 247.0℃. Regarding their odors, methyl parahydroxybenzoate and ethyl parahydroxybenzoate as raw materials have a slight odor.

2）Preparation of experimental towels

We used 2 types of towels with different surface coarseness levels (coarse : 20×30cm and 7 meshes/cm 2 ; and fine : 20×30cm and 22 meshes/㎠) (Figure 1). Unifying the size and weight of all towels and the volume of the bed-bathing solution applied to them, we prepared 8 sets of a coarse double sheet of 15 g (a total of 120 g) and 8 sets of a fine triple sheet of 15 g (120 g). The bed-bathing solution was applied to all towels at 150 mL, which was the maximum possible volume to be applied without dripping even when the towels were grasped. Both types of towels were then folded to palm size (13×8cm). After these processes, the 2 types of towels were equal in size and weight, and prepared for comparisons of their bed-bathing effects based only on surface coarseness levels. The towels were stored in a bed bath container at a constant temperature (81.0±6.6℃) to maintain coarse towels at 53.1±5.7℃ and fine towels at 54.3±4.3℃.

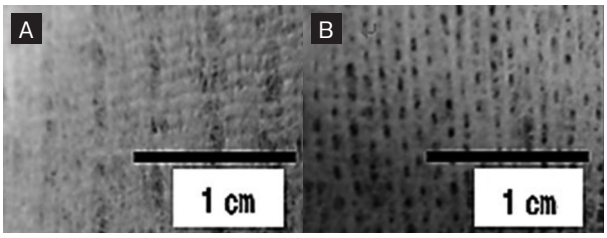


Figure1. Surface of synthetic towel fabric.

3）Bed-bathing environment

We prepared 2 beds for complete bed baths, and alternately used them to avoid the warmth of the last participant's body remaining on the bed sheet until the next session. Regarding each participant, we measured room temperature, humidity, illumination, and noise levels, which may influence measurement data. During each bed bath, a room temperature of 24.3±1.7℃ and humidity of 43.2±4.3% were maintained, with an illumination intensity and noise level of 35.1±6.1 Lux and 46.4±4.9 dB, respectively.

4）Bed-bathing procedure

We prepared 2 beds for complete bed baths, and alternately used them to avoid the warmth of the last participant's body remaining on the bed sheet until the next session. To unify the quality of bed bathing, the same practitioner performed the procedure for all participants. The towels were folded to palm size (13×8cm). The length and force of each wipe was approximately 23 to 25cm and 0.57±0.04 kgf/㎠, respectively. 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 the towel, a new one was selected, and 2 sets of 5 repetitions of upward and downward wipes were performed along the spine from the posterior region of the neck to the lower back on the left and right sides. Participants were then placed in a supine position, and 3 repetitions of upward and downward wipes were performed along both arms, neck, chest, abdomen, and both legs in that order. This unified bed-bathing procedure was performed on all participants. Towels were changed whenever the region was shifted. The facial, genital, and gluteal areas were excluded in all cases.

2. Data collection

1）Measurement of subjective indices

To subjectively compare the heat-retaining properties and textures of cotton and synthetic materials, we used a short Japanese version of the Profile of Mood States (POMS-J)[12] and Visual Analogue Scale (VAS)[13),14)] (Figure2). We examined participants' psychological conditions before and after complete 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 complete bed baths. Thirty questions were answered on a 5-point scale (0－4 points). We used the following formula to standardize POMS-J scores as T-scores based on the raw scores obtained for each question : [T-score=50+10×(raw score-mean/standard deviation)]. Similarly, we assessed the levels of wakefulness and relaxation using VAS.

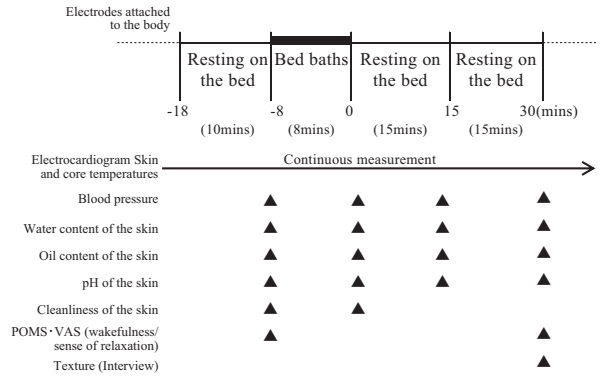


Figure.2　Experimental protocol
▲ represents the point of measurement for each index.

A 100-mm horizontal line was presented to each participant, with the descriptions of <No : 0> and <Yes : 100> at the left and right ends, respectively. We traced the

line using a finger, and a vertical line was drawn at the point indicated by the participant.We also asked participants about their impressions of the texture of each material 30 minutes after the completion of bed bathing. We examined 7 aspects of texture, based on the findings of a previous study[8] :<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 <No>(1)to <Yes> (3).

2) Measurement of objective indices

To objectively compare the effects of complete bed baths using towels with and without the bed-bathing solution, we measured skin temperature, core temperature, HR, skin moisture and oil contents, skin surface pH and cleanliness levels, and blood pressure. We used the following devices for these measurements : skin temperature : a digital clinical thermometer for continuous measurements, Terumo Finer CTM-303 (Terumo Corporation) ; core temperature : a zero-heat-flow clinical thermometer, Coretemp CM-210 (Terumo Corporation) ; HR : an electrocardiogram, MemCalc/Tarawa (GMS Co., Ltd.) ; skin moisture content : Corneometer® CM 825 (Courage + Khazaka electronic GmbH) ; skin oil content : Sebu-meter®SM 810 (Courage + Khazaka electronic GmbH) ; skin surface pH level : Skin pH Meter® PH 900 (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 measurements to 4 regions : the anterior chest (midpoint between both papillae), right forearm(midpoint between the elbow and wrist joints), right fourth finger pulp, and first toe of the left foot. When measuring the core temperature, we covered the probe (Core Temperature Probe PD 1, 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 using tape with a width of 2.5㎝. We performed electrocardiography adopting the 3-lead method.

We measured skin moisture and oil contents, surface pH levels, and cleanliness at the left cervical region. In the skin cleanliness evaluation, we measured ATP activity levels. 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 selected the left cervical region for these measurements because it does not require positioning or the removal of blankets, and consequently has a weaker influence on autonomic activity. We examined skin in the following order for the same reason : skin moisture content > oil content > surface pH level > cleanliness level. The measurement site in the left cervical region was a section with a width of 40×40㎜ with its center 50㎜ above a fourth of the clavicle from the sternal end. We measured skin moisture content and surface pH levels three times to adopt a mean at each point. We measured skin oil content and the cleanliness level once, and adopted a mean at each point. In each measurement of skin moisture/oil content or surface pH, we slightly shifted the site of measurement within the left cervical region. We measured skin cleanliness levels 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 with it 5 times.

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

3. Experimental procedure

We instructed participants to stop eating and drinking 2 hours before the initiation of the experiment. Prior to the experiment, participants wore a patient gown and short pants over underwear in a dressing room, and moved with slippers on their feet. In another room, we provided them with an outline of the experiment and confirmed their current health conditions.

We guided each participant to a private room for complete 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 core and skin temperature

measurements and electrodes for electrocardiography to the 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-bathing procedure for 8 minutes. After the completion of bed bathing, a 30 minute bed rest period was initiated. Thus, the duration of the entire process was 50 minutes. During the initial bed rest period, we conducted evaluations using POMS-J and VAS（wakefulness/relaxation）. Immediately before bed bathing, we measured blood pressure, skin moisture and oil contents, and skin surface pH and cleanliness levels. Participants closed their eyes during complete bed baths. We measured blood pressure, skin moisture and oil contents, and skin surface pH levels immediately after and then 15 and 30 minutes after the completion of bed bathing, as well as skin cleanliness levels immediately after the completion of bed bathing. Thirty minutes after the completion of bed bathing, we again conducted evaluations using POMS-J and VAS（wakefulness/relaxation）, and examined the participants' impressions of the texture of each towel material. We continuously measured electrocardiographic values and core and skin temperatures throughout the experiment.

Verbal communication with participants during the experiment was limited to the following : 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.Towels with and without the bed-bathing solution were similarly used under these conditions.

All 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. During both sessions, the bed-bathing procedure was performed using towels with and without the bed-bathing solution. The order of using towels for the 2 experimental sessions was randomly selected.

6. Data analysis

We analyzed all data collected using the statistical software SPSS Ver. 24.0 for Windows. We calculated the autonomic activity level by analyzing electrocardiographic data, adopting the maximum entropy method（Mem Calc/Tarawa, GMS Co., Ltd.）. In a frequency analysis, we set the low（LF）and high（HF）frequency components of HR 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 data on HR and parasympathetic（HF）and sympathetic（LF/HF）activities during each of the following stable 2 minute periods : before bed bathing（from 3 minutes after the initiation of rest）, immediately before the completion of bed bathing（from 6 minutes after the initiation of bed bathing）, 15 minutes after the completion of bed bathing（from 11 minutes after the completion of bed bathing）, and 30 minutes after the completion of bed bathing（from 23 minutes after the completion of bed bathing）. We chronologically compared the data obtained immediately before, 15 minutes after, and 30 minutes after the completion of bed bathing with those obtained before bed bathing as baseline values. At the same time, we compared the extent of the change in each value at each point when using towels with and without the bed-bathing solution. Regarding HR, the value obtained 15 minutes after the completion of bed bathing slightly varied between the groups. Therefore, we used the value before bed bathing as the baseline value（0）to compare the extent of the change observed.

We also examined chronological changes in core and skin temperatures immediately before and 15 and 30 minutes after the completion of bed bathing with those before bed bathing as baseline values. In both cases, we compared the extent of the change at each point between the groups. We also examined chronological changes in skin moisture/oil contents and surface pH levels immediately before, immediately after, 15 minutes after, and 30 minutes after the completion of bed bathing with those before bed bathing as baseline values, and compared the extent of the change observed at each point between the groups in all cases. Regarding ATP activity as an index of skin cleanliness, we calculated the change rate immediately after the completion of bed bathing, with the value before bed bathing as the baseline value（0）for comparisons. We also compared moods before and after bed bathing based on POMS-J and VAS scores, and examined the impression of the texture of each type of towel after bed bathing. We used non-parametric tests in statistical analyses. We conducted the Friedman test for intra-group comparisons of measurement values, and the Wilcoxon signed-rank test for inter-group comparisons using the extent of the change based on the value during the rest period before bed bathing. We used the chi-squared test for comparisons of the impression of texture after bed bathing between the 2 types of towels. In all cases, we set the significance level at <5%.

Ethical considerations

We provided participants with written and oral explanations of the study objective, assurance of the right to freely make decisions, protection of privacy, maintenance of confidentiality, avoidance of disadvantageous treatment, acceptance of withdrawal at any time, and the publication of results to obtain their signed consent. This study was conducted with the approval of the ethical review board of Department of Nursing, Faculty of Health Sciences, Kagawa Prefectural University (No.203).

Results

We examined the effects of complete bed baths (excluding the facial and genital areas) on 15 healthy male students, performed through a unified procedure using towels with different surface coarseness levels (coarse/fine).

1. Comparisons based on subjective indices

In comparisons of participants' impressions of the textures of coarse and fine towels, more than 50% answered <Yes> for6out of the 7 texture-related statements (<Warm>, <Favorable texture>, <Feeling comfortable when being wiped>, <Feeling refreshed>, <A sense of fitness>, and <Feeling that the body has been cleaned >) in both cases. The rates of answering that coarse and fine towels are <Soft> were 50 and 30%, respectively. Coarse towels achieved a significantly higher rate of answering <Yes> for <Feeling comfortable when being wiped> (P<.05) (Table 1).

In comparisons of participants' levels of wakefulness and relaxation before and after bed bathing based on their VAS scores, both levels significantly increased after bed bathing (P<.05 and P<.01, respectively). Similarly, in comparisons of moods before and after bed bathing based on POMS-J scores, marked decreases were noted in the scores for <tension-anxiety>, <fatigue>, and <confusion> after the completion of the procedure. When coarse towels were used, scores for <anger-hostility> and <vigor> also decreased after the completion of bed bathing (Figure 3 and 4), and a significant difference was observed in <depression>-related scores. In contrast, when using fine towels, scores for these 3 subscales increased.

Table1 Texture of the materials of towels

Item	Responses	Coarse n=15	Fine n=15	χ^2
Soft	Yes	7	4	
	Neutral	5	10	5. 8
	No	3	1	n.s.
Warm	Yes	11	14	
	Neutral	3	1	4. 3
	No	1	0	n.s.
Favorable texture	Yes	11	10	
	Neutral	4	3	0. 9
	No	0	2	n.s.
Feeling comfortable when being wiped	Yes	13	11	
	Neutral	1	2	13. 9
	No	1	2	*
Feeling refreshed	Yes	9	12	
	Neutral	5	3	4. 4
	No	1	0	n.s.
Feeling a sense of fitness	Yes	9	8	
	Neutral	6	5	2. 2
	No	0	2	n.s.
Feeling that the body has been cleaned	Yes	9	9	
	Neutral	5	6	1. 7
	No	1	0	n.s.

Note 1) Numerical values in the table represent the number of subjects [Coarse towels (n=15), Fine towels (n=15)].
Note 2) 2 test.* P<.05
Note 3) The results of inter-group comparisons were not significant.

2. Comparisons based on objective indices

To clarify the influence of differences in bed-bathing effects between the 2 types of towels with different surface coarseness levels (coarse/fine) on the human body, we examined the results of analyses based on each physiological index. Each figure compared the following index values : Figure 5 : core and skin temperatures ; Figure 6 : blood pressure as a hemodynamic index ; Figure 7 : HR and autonomic activity ; Figure 8 : skin moisture/oil contents and surface pH levels ; and Figure 9 : skin cleanliness levels.

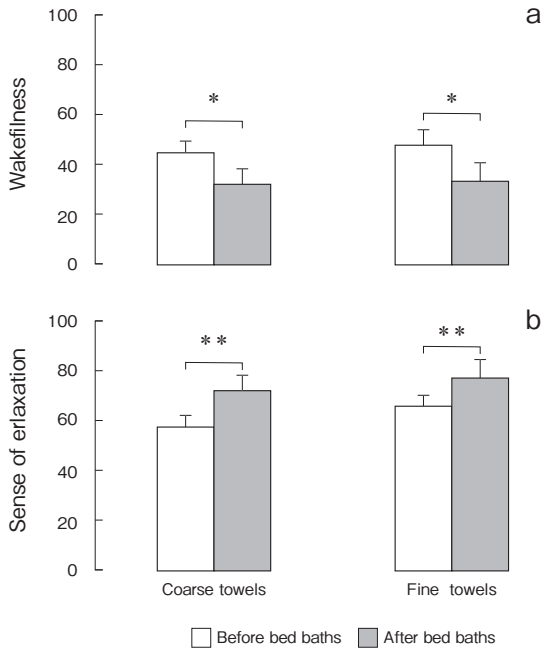


Figure 3 : Changes in VAS for wakefulness and the sense of relaxation following bed baths
Note 1) Coarse towels (n=15), Fine towels (n=15). Numerical values are expressed as "Mean±SE"
Note 2) Wilcoxon signed-rank tests were used to compare values prior to and following the intervention. * P<.05, ** P<.01

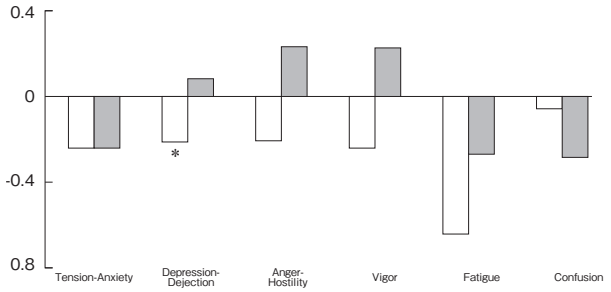
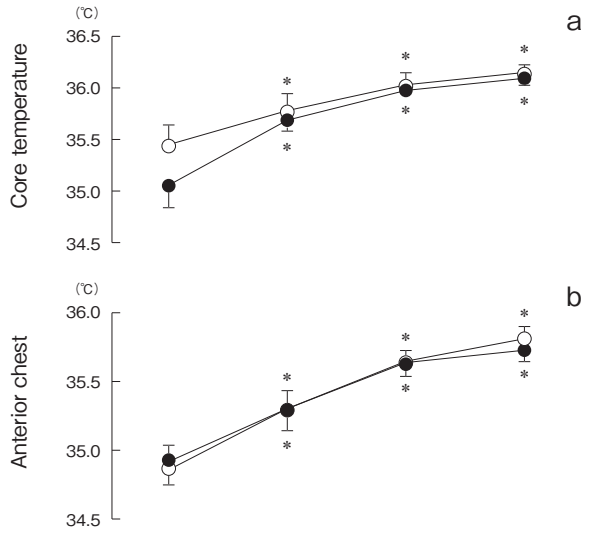


Figure 4 Comparison of coarse and fine towels prior to and following bed baths using the short version of POMS-J
Note 1）□ Coarse towels（n=15），▨ Fine towels（n=15）Numerical values are T scores calculated using the following formula：[50+10(raw score-mean/SD)]. Numerical values are expressed as "After Mean-Before Mean"
Note 2）Values obtained before and after the intervention were compared using the Wilcoxon signed-rank test.

A marked increase of approximately 0.9℃ was noted in the core temperature from immediately before to 30 minutes after the completion of bed bathing when using both the coarse and fine towels. The skin temperatures of the anterior chest（approximately 0.9℃）and first toe of the left foot(approximately 3.9℃）also markedly increased(Figure 5 a, b, and e), while that of the right forearm showed a significant increase of approximately 1.0 ℃ from 15 minutes after the completion of bed bathing to the final measurement point（Figure 5 c)(P <.05 in all cases). Regarding the fourth finger pulp of the right hand, skin temperature decreased by approximately 0.8 ℃ during bed bathing, increased by approximately 1.0℃ 15 minutes after its completion, and decreased again by approximately 0.1℃ at the final measurement point when using coarse towels. When using fine towels, it decreased by approximately 0.6℃ during bed bathing（P <.01), and increased by approximately 1.0℃ 15 minutes after the completion of bed bathing. The increase of approximately 1.0℃ was maintained until 30 minutes after the completion of bed bathing.(Figure 5 d).



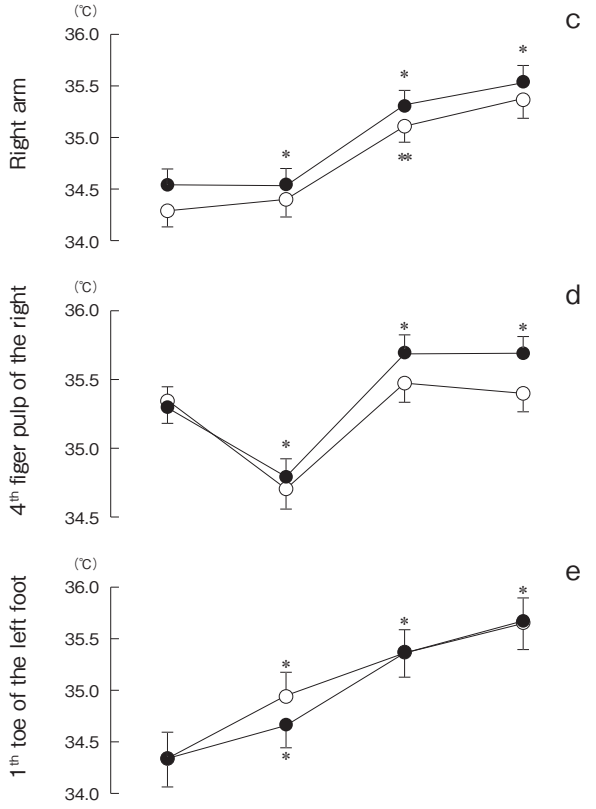


Figure 5 Changes in core and skin temperatures after bed baths using coarse and fine towels
Note 1）○ Coarse towels(n=15)，● Fine towels(n=15)．Numerical values are expressed as "Mean ± SE"
Note 2）Following Friedman's test, values obtained before and after the intervention were compared using the Wilcoxon signed-rank test. * P<.05, ** P<.01
Note 3）The results of inter-group comparisons were not significant.

When we focused on blood pressure levels during complete bed baths using the 2 types of towels, the extent of changes ranged between 1.8 and-4.6 mmHg.When using coarse towels, diastolic blood pressure increased（approximately 2.5 mmHg）immediately after the completion of bed bathing, whereas significant decreases were observed in systolic and diastolic blood pressure（approximately-4.2 mmHg）15 minutes after the completion of bed bathing with fine towels（P <.05）（Figure 6).

A variability analysis using electrocardiographic records（Figure 7）revealed slight decreases in HR（approximately 3.5 bpm）from immediately before to 15 minutes after the completion of bed bathing, followed by an increase when using coarse towels. When using fine towels, HR initially increased（approximately 0.9 bpm）immediately before the completion of bed bathing, subsequently decreased(-1.4 bpm) 15 minutes after the completion of bed bathing（P <.01), and then increased again（approximately 2.1 bpm）(Figure 7 a). In both cases, parasympathetic activity levels（HF）began to increase immediately before the completion of bed bathing, show-

ing a significant increase 15 minutes after the completion of bed bathing ($P<.01$ and $P<.05$, respectively); however, it finally decreased, and this decrease was only significant when coarse towels were used ($P<.05$) (Figure 7 b). Furthermore, when coarse towels were used, sympathetic activity levels (LF/HF) began to increase immediately before the completion of bed bathing, showing a significant increase 15 minutes after the completion of bed bathing ($P<.05$), and this increase continued until the final measurement point.In contrast, when using fine towels, sympathetic activity levels (LF/HF) significantly increased immediately before the completion of bed bathing, subsequently decreased, and showed a significant increase at the final measurement point ($P<.05$) (Figure 7 c).

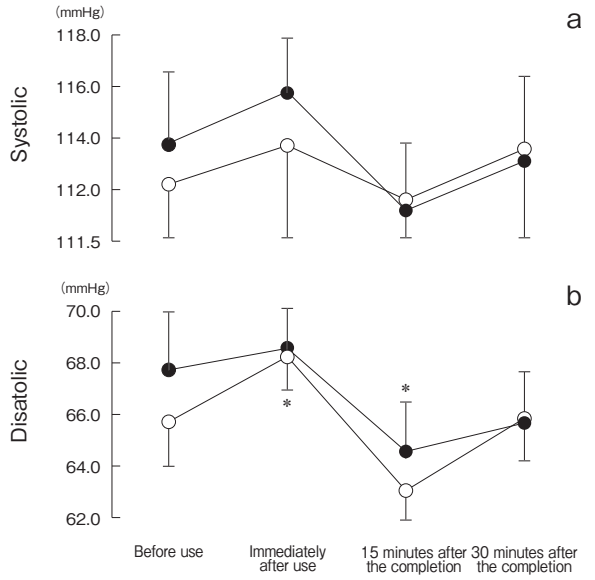


Figure 6 Changes in blood pressure after bed baths using coarse and fine towels
Note 1) ○ Coarse towels (n=15), ● Fine towels (n=15). Numerical values are expressed as "Mean ± SE"
Note 2) Numerical values in the table are expressed as "Mean±SE".
Note 3) Following Friedman's test, values obtained before and after the intervention were compared using the Wilcoxon signed-rank test. * $P<.05$
Note 4) The results of inter-group comparisons were not significant.

Figure 8 shows skin moisture/oil contents and surface pH levels. A significant increase was observed in skin moisture content immediately after the completion of bed bathing with coarse and fine towels; this value increased by approximately 10 ($P<.05$) and 12.4% ($P<.01$), respectively. The rates of decreases 15 minutes after the completion of bed bathing with coarse and fine towels were approximately 6.7 and 8.5% ($P<.05$), respectively, whereas the total rates of increases from the baseline were approximately 1.5 and 2.2%, respectively, at the final measurement point (Figure 8 a). Skin oil content significantly decreased (approximately-7.1 $\mu g/cm^2$) immediately before the completion of bed bathing

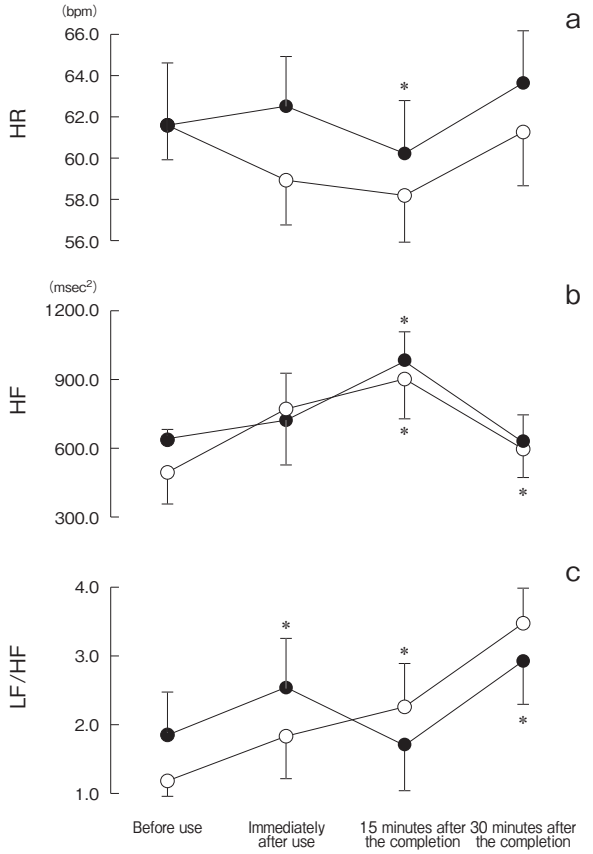


Figure 7 Changes in HR, HF, and LF/HF after bed baths using coarse and fine towels
Note 1) ○ Coarse towels (n=15), ● Fine towels (n=15). Numerical values are expressed as "Mean ± SE"
Note 2) "HR", "HF", and "LF/HF" represent heart rate and parasympathetic and sympathetic activities, respectively.
Note 3) Following Friedman's test, values obtained before and after the intervention were compared using the Wilcoxon signed-rank test. * $P<.05$, ** $P<.01$
Note 4) The results of inter-group comparisons were not significant.

($P<.05$), showing a slight increase during the subsequent period and a slight decrease when using coarse towels. In contrast, when using fine towels, a significant decrease was observed (approximately-8.3) immediately before ($P<.05$) and 15 minutes after the completion of bed bathing ($P<.01$); however, this value finally increased ($P<.01$) (Figure 8 b). Skin surface pH levels significantly increased (0.3) immediately before the completion of bed bathing ($P<.05$), was maintained until the final measurement point, with significant differences ($P<.01$) when using coarse towels.When using fine towels, skin surface pH levels significantly increased (0.2) immediately before the completion of bed bathing ($P<.05$), and had further increased 15 minutes after the completion of bed bathing ($P<.01$), but finally decreased ($P<.01$) (Figure 8 c). In comparisons of the rates of changes in skin cleanliness levels between before and after bed bathing when using coarse and fine towels, significant increases were noted after it, at 46.5% ($P<.05$) and 79.3% ($P<.05$), respectively (Figure 9).

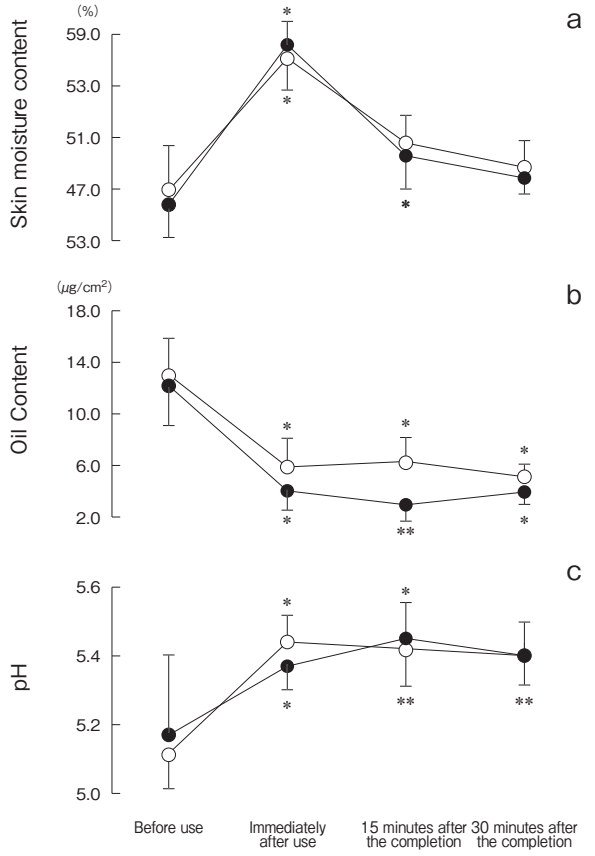


Figure 8 Changes in skin moisture content, oil content, pH after bed baths using coarse and fine towels
Note 1）○ Coarse towels (n=15), ● Fine towels (n=15). Numerical values are expressed as "Mean ± SE"
Note 2）Following Friedman's test, values obtained before and after the intervention were compared using the Wilcoxon signed-rank test. * P<.05, ** P<.01
Note 3）The results of inter-group comparisons were not significant.

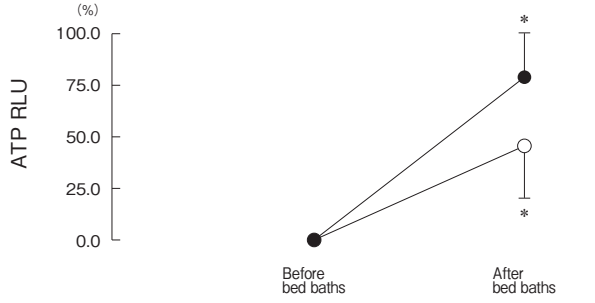


Figure 9 Changes in skin moisture content, oil content, pH after bed baths using coarse and fine towels
Note 1）○ Coarse towels (n=15), ● Fine towels (n=15). Numerical values are expressed as "Mean ± SE"
Note 2）Numerical values obtained before and after the intervention were compared using the Wilcoxon signed-rank test. * P<.05
Note 3）The results of inter-group comparisons were not significant.

Discussion

We compared the effects of complete bed baths using 2 types of synthetic towels with different surface coarseness levels (coarse/fine) on healthy male students, and examined the influence of this difference on the human body. The results obtained revealed differences between the 2 types of towels.In this section, we discuss these differences from the perspective of texture, moisturizing effects, and cleanliness in that order.

1. Comparison of texture based on surface coarseness levels

In our previous studies, a tactile/pressure stimulation with fabrics with coarse surfaces was proven to activate parasympathetic nerves (HF) and suppress sympathetic nerves (LF/HF) [9),10)]. These fabrics included synthetic mesh and looped cotton towels.Their surface coarseness levels are commonly high.

The present experiment showed subjective superiority of coarse towels with 7 meshes/cm^2 to fine towels with 22 meshes/cm 2 for creating a comfortable feeling with a coarse surface in contact with the skin.When using coarse towels ; scores for <Feeling comfortable when being wiped> were higher (P <.05), and scores for all POMS-J subscales also decreased after the completion of bed bathing, and a significant difference was observed in depression-related scores (P <.05). In contrast, when using fine towels, no significant differences were noted for any aspect of texture, and the scores for 3 POMS-J subscales increased, while those for 3 other subscales decreased, suggesting unstable moods (Figures 3 and 4). These results are mostly consistent with the findings of our previous study, in which synthetic towels without surface coarseness did not achieve a favorable texture[10)]. Thus, fine towels with a lower surface coarseness level may not have provided a sufficient tactile/pressure stimulation, resulting in a poorer texture.

In the examination of each objective index, a significant decrease was observed in HR, with a significant increase in parasympathetic activity levels (HF) from during bed bathing to 15 minutes after its completion when using coarse towels, clearly indicating that the tactile/pressure stimulation to the skin provided by these towels was comfortable. The surface coarseness level of coarse towels was higher than that of fine towels, and this coarse surface may have created a stronger stimulation perceived by tactile/pressure receptors in tissues, such as the skin and muscles, which was conveyed to the cerebral cortex through nerves[15)], consequently creating a comfortable tactile/pressure feeling, as suggested in the subjective evaluation. The tactile/pressure stimulation to the skin by fine towels was insufficient, and their texture did not create a comfortable feeling. In analyses of core and skin temperatures, both indices showed similar variabilities. On the other hand, heat-retaining effects

lasted longer with fine than with coarse towels, possibly as a result of a lower rate of heat loss from interfilament spaces. A solution containing alcohols, such as propylene glycol, ethanol, and phenoxyethanol, was applied to both types of towels. Even when heated, the high volatility of alcohol contained in these components at a trace amount promotes heat loss, contracts peripheral blood vessels, and reduces skin blood flow, leading to a sudden decrease in skin temperature. Warm blood in the surface layer of the skin then moves back to the trunk and increases peripheral skin blood flow[16]. In the present study, ethanol, which dilated the peripheral blood vessels of the fingertip (fourth finger pulp of the right hand), may have rapidly increased the skin temperature of the fingertip 15 minutes after the completion of bed bathing. When focusing on the skin temperature of the fingertip, fine towels with smaller interfilament spaces were superior to the coarse towels for preventing heat loss, thereby explaining the longer duration of heat retention observed. Based on this result, reduced HR (approximately-2. 3bpm), increased parasympathetic activity levels ($P<.05$), and decreased systolic and diastolic blood pressure levels ($P<.05$) observed 15 minutes after the completion of bed bathing when using fine towels may have resulted from an increase in blood flow and reduction in peripheral blood vessel resistance associated with the dilation of peripheral blood vessels 17) (Figure 6). The autonomic nervous system is responsible for vasomotor regulation with lasting heat-retaining effects and the circulatory reflex. However, 30 minutes after the completion of bed bathing, HR increased and parasympathetic activity level (HF) decreased, with elevated sympathetic activity levels (LF/HF), regardless of the type of towel. These results suggest that both types of towels lacked sufficient surface coarseness as the comfortable feeling was not maintained until the final measurement point.

In brief, subjective evaluations to compare the heat-retaining properties and textures of the 2 types of towels revealed that coarse towels were superior to fine towels for enhancing comfort based on autonomic activity levels, core/skin temperature, and blood pressure. On the other hand, the values representing autonomic activity indicated that surface coarseness levels were still insufficient because the comfortable feeling was not maintained until 30 minutes after the completion of bed bathing. Therefore, further studies are warranted.

2. Comparison of moisturizing effects with different surface coarseness levels

The skin consists of 3 layers, the epidermis, dermis, and subcutaneous. The most superficial layer of the epidermis is the stratum corneum, followed by the stratum granulosum, stratum spinosum, and stratum basale in that order. Sebum in the stratum corneum functions as a barrier on the skin to prevent the loss of skin surface moisture[18]. In the present study, the moisture content of the skin surface from immediately to 15 minutes after the completion of bed bathing was higher with fine towels than with coarse towels. In both cases, ethanol as an alcohol with high volatility and degreasing activity may have led to a dry skin surface by promoting moisture loss ; however, it is important to note that the skin contact area during bed bathing was larger when using fine towels with 22 meshes/cm^2 than with coarse towels with 7 meshes/cm^2. Thus, the former may have achieved greater moisturizing effects because propylene glycol (a moisturizing, lubricating, emulsifying, and antiseptic component), which was also contained in the bed-bathing solution, promoted percutaneous water absorption, consequently swelling and moisturizing the stratum corneum and increasing skin moisture content.

Sebaceous glands secreting sebum are the most concentrated in the face and scalp, at 400 to 900 glands/cm^2, followed by the chest, back, and neck[19]. In the present study, the decrease in skin oil content immediately after the completion of bed bathing was more prominent when using fine towels (amount of decrease : 8.3 $\mu g/cm^2$) than coarse towels (7.1 $\mu g/cm^2$), suggesting that the former exerted greater degreasing effects. Due to the presence of fatty acids and lactate in sweat covering the skin surface, normal skin pH levels are generally maintained on the slightly acidic side, at 4.2-6.4. Increased pH levels negatively affect skin barrier function[20]. Therefore, propylene glycol as a moisturizing, lubricating, emulsifying, and antiseptic component may have contributed to the retention of skin moisture and maintenance of skin barrier function after bed bathing when using coarse towels because stable skin oil content and surface pH levels were maintained until 15 to 30 minutes after the completion of the procedure. When using fine towels, decreases were observed in skin oil content immediately and 15 minutes after the completion of bed bathing, with the skin surface pH level continuing to increase until 30 minutes after the procedure. As a general characteristic of dry skin, the skin surface pH level gradually increases due to the poor control of water vapor loss from the inside[21]. On the other hand, in the present study, a higher skin cleanliness level was achieved with fine towels (79.3%) than with coarse towels (46.5%). Although clear

skin dryness was not observed, even 30 minutes after the completion of bed bathing, an increase was noted in skin surface pH levels, and the possibility of the skin surface lacking moisture due to the removal of sebum, natural moisturizers in the epidermis, and even intercellular lipids in the corneum[18] is undeniable.

In summary, skin moisture content significantly increased immediately after the completion of bed bathing, with a temporary and marked decrease in skin oil content and increase in skin surface pH levels, similarly when using coarse and fine towels. However, when using coarse towels, skin moisture and oil contents and surface pH levels were maintained until 15 to 30 minutes after the completion of bed bathing, indicating improved skin surface moisturizing effects.

Conclusion

We compared the effects of complete bed baths using 2 types of towels : coarse and fine, in a simulated clinical setting. Subjective evaluations revealed the superiority of coarse to fine towels for creating a comfortable feeling with a favorable texture when used as a bed-bathing material. Moisture-retaining and cleaning effects were similar between the 2 types of towels ; however, coarse towels stably retained moisture for a longer time period.

On the other hand, a sense of comfort was only temporarily enhanced and was not maintained until the final point in either case, revealing that the surface coarseness levels of both types of towels were still insufficient. As future perspectives, we will continue to focus on the surface coarseness levels of synthetic towels, and examine appropriate materials and surface profiles to enhance physiological/subjective comfort.

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化繊タオルの生地表面の形状の違いが及ぼす全身清拭効果の比較

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要旨

目的：化繊タオルの生地表面の形状の違い（粗い目，細かい目）が全身清拭効果に及ぼす影響を比較検討する．

方法：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：両者とも終了直後の水分量が増大，油分量が低下，ｐＨが上昇した（P <.05）が，粗い目ではそれらが最終まで一定に保持され，終了後の心地よい肌触り感，ＰＯＭＳの評点の減少，終了15分後まで心拍数の減少と副交感神経活性の上昇が見られた（P <.05）．細かい目タオルでは心地よい肌触り感には至らず，終了15分後のみに心拍数の減少と副交感神経活性の上昇，交感神経活性の低下が見られた（P <.05）．

結論：粗い目のほうが細かい目に比べ，心地よい肌触り感に優れ主観的評価を支持する結果であり一定した保湿性に優れていた．

Key Words：化繊タオル，生地表面の違い，粗い目，細かい目，全身清拭効果

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