Effect of Wiping Pressure on Body Hygiene of Bed Bath with a Wet Washcloth

Suga, Sayaka
Ishii, Atsue
Nakanishi, Yoshitaka

(Citation)
Bulletin of health sciences Kobe,38:45-56

(Issue Date)
2023

(Resource Type)
departmental bulletin paper

(Version)
Version of Record

(JaLCDOI)
https://doi.org/10.24546/0100481687

(URL)
https://hdl.handle.net/20.500.14094/0100481687

Effect of Wiping Pressure on Body Hygiene of Bed Bath with a Wet Washcloth

Sayaka SUGA [1], Atsue ISHII [1], Yoshitaka NAKANISHI [2]

Abstract

Introduction: Dirt on the skin can be removed by friction, and the properties of wiping materials and wiping pressure are related to the friction coefficient of the skin. In the current study, we examined the possible relationships between wiping pressure and skin hygiene.

Materials and Methods: The study subject was one healthy female in her twenties. The wiping pressure was measured using a pressure-sensitive film sheet attached to the skin. An adenosine triphosphate hygiene monitoring test was conducted as an indicator of skin hygiene, which was measured as the level of relative light units (RLU). We conducted an experiment 10 times on the left and right lower legs. A correlation analysis was conducted to examine the relationship between RLU level and wiping pressure.

Results: No significant correlation was found between the reduction in RLU level by bed bathing and wiping pressure ($r = -0.04$; $P = 0.79$).

Conclusion: The current findings did not indicate a clear relationship between wiping pressure and removing dirt from the skin during a bed bath. These results suggest the possibility that dirt can be removed and hygiene can be maintained regardless of the wiping pressure.

Keywords

Bathing, Hygiene, Nursing care

[1] Department of Nursing, Graduate School of Health Sciences, Kobe University, Japan

[2] Faculty of Advanced Science and Technology, Kumamoto University, Japan

Introduction

Whole-body hygiene care is important for maintaining skin integrity through the removal of dirt and microorganisms from the skin [1]. Hygiene is considered to be a fundamental component of the care provided by nurses to every patient [2]. Whole-body hygiene care includes bathing, shower bathing, and bed bathing. Bed bathing satisfies hygiene needs of bed-ridden patients who have acute or chronic diseases [3]. Patients who cannot maintain hygiene on their own often receive bed baths, and are largely reliant on nurses for this part of their care. Nurses are expected to conduct bed baths using appropriate techniques.

Dirt on the skin is removed by friction between the skin and the wiping materials [4]. The major factors related to friction on the skin are skin hydration, the properties of the wiping materials, and wiping pressure [5]. A previous study conducted a comparison between bed bathing, washing with a washcloth, and cleaning without water using nonwoven fabric, as means of maintaining skin hygiene [6]. Other research examined the effects of the mechanical stimulation of friction on skin abnormalities and lesions [7]. These studies did not directly examine the friction coefficient, but investigated the effects of materials on bed bath, from various perspectives.

It has been suggested that wiping pressure is also related to friction on the skin [5], but only a few studies have examined wiping pressure. Mechanical stimulation and excessive friction can cause damage to the skin. To establish safe bed bath techniques, it is necessary to consider the appropriate wiping pressure for removing dirt from the skin. It is technically difficult to measure wiping pressure during bed baths. One previous study used a pressure-sensitive mat placed under the arm to measure wiping pressure [8]. However, because wiping pressure was measured indirectly, the results might not accurately reflect the contact pressure applied to the skin during the bed bath. Therefore, in the current study, we directly measured wiping pressure by attaching a pressure-sensitive film sheet on the skin and examining the relationship between wiping pressure and skin hygiene.

Materials and Methods

1. Study participants

Previous studies have reported substantial variation in the level of relative light units (RLU) before bed bathing among individuals [9, 10]. To minimize the effect of individual differences in the state of the skin, in the current study we examined a single study participant, who was a healthy Asian woman in her twenties.

2. Study conditions

We conducted the experiment in a laboratory in which the room temperature and humidity could be controlled. We set the room temperature to 25°C and room humidity to 50%, and the study participant remained seated and relaxed for more than 10 minutes before the experiment. The experiment was

conducted from 10:00 a.m. to 11:30 a.m. To minimize the effects of climate, the study was conducted within a 1-month period.

3. Experimental procedure

3.1. Wiping areas

The participant sat on a chair with the knee joints bent at 90° and the soles of the feet on the floor. In that posture, we first determined the middle point of the straight line on the medial condyle and inner malleolus. Second, we set reference points that were 2 cm above and below the determined middle point. Third, 10 × 10 cm wiping areas (A, B, C and, D) were determined on the basis of the reference point, as shown in Fig 1. The outer boundaries of the wiping areas were marked with tape.

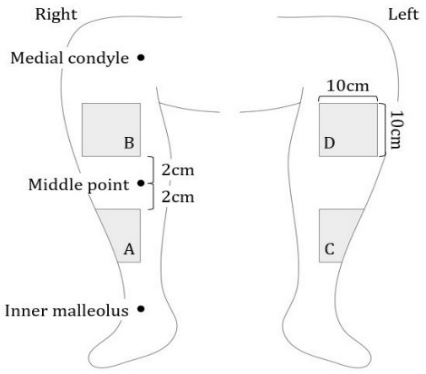

Fig 1. Wiping areas

3.2. Method for measuring wiping pressure

Wiping pressure was measured with an Economical Load and Measurement (ELF™) System, which is a load measurement tool using a FlexiForce® sensor (Tekscan, Inc., Boston, MA, USA). The pressure sensor was a film with a width of 14 mm, length of 205 mm, and thickness of 0.208 mm, and the sensing area to detect the load was a circular area with a diameter of 9.5 mm. The measurement unit of the sensor was grams (g), and the maximum measured pressure while wiping was taken to be the wiping pressure in the current study.

Previous studies have examined the use of the FlexiForce sensor on soft surfaces such as the human body [11, 12]. It has been suggested that the pressure measurement with FlexiForce is more accurate when it is placed on a hard surface than on a soft surface, because of the deformation on the soft surface of the film [11, 12]. It has been reported that placing a thin-film sensor on a soft surface less than 3 mm thick results in small impact on the measured pressure [12]. In the current study, the sensing area of the pressure sensor was placed close to the center of each wiping area over the tibia. Because the sensor was placed over the tibia, the subcutaneous tissue was thin, and the tibia felt hard beneath the surface of the skin (Fig. 2). To fix the pressure sensor, we used a Transparent Film Dressing Catereep® FS Roll (Nichiban Co., Ltd, Tokyo, Japan) with a width of 3 cm, length of 5 cm, and thickness of 25 μm.

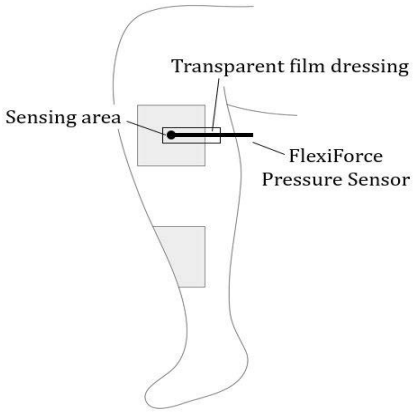

Fig 2. Placement of the pressure

3.3. Bed bath procedure

We used an all-cotton washcloth with a width of 32.5 cm and length of 32.5 cm for the bed bath. The dampened washcloth was heated in a microwave to 52°C. Each wiping area was wiped back-and-forth evenly once from the periphery to the center, with no overlap on the wiping area. We conducted the wiping experiment in the following order: area A, followed by areas B, C, and D (Fig 1). The experiment was conducted independently for each wiping area, and we used a new washcloth for each wiping area. The bed bath was performed by the same experimenter each time, so that the procedure would be consistent.

3.4. Procedure of adenosine triphosphate (ATP) hygiene monitoring test

An ATP hygiene monitoring test was conducted as an indicator of skin hygiene with a Lumitester PD-20 and LuciPac® Pen (Kikkoman Biochemifa Co., Ltd, Tokyo, Japan). This test is a measure of skin hygiene, which is measured by RLU level.

ATP is an energy molecule contained in all organic matter [13, 14]. ATP is a biomarker of substances derived from organisms, and the approximate amount of organic matter can be determined by measuring the ATP level [15]. The ATP hygiene monitoring test employs the bioluminescent reaction of luciferase to measure the ATP level. Reacting ATP with luciferin, Mg^{2+}, and oxygen results in adenosine monophosphate (AMP), pyrophosphate, carbon dioxide, oxyluciferin, and the generation of luminescence. The ATP hygiene monitoring test uses the ATP-AMP enzymatic cycling method. AMP and pyrophosphate are reconverted to ATP with pyruvate orthophosphate dikinase (PPDK), which enables stable luminescence. The ATP level is calculated by measuring this luminescence by RLU level [13].

A positive correlation between ATP level and microbial counts has been reported in previous studies [16, 17]. The ATP hygiene monitoring test provides stable and high luminescence [13]. The ATP hygiene monitoring test has been used as an indicator of hygiene [13] in healthcare settings [18, 19], and as a measure of hand hygiene [20]. Standardized RLU level values for hands and fingers have been published

[21, 22]. In the current study, we measured the RLU level using the ATP hygiene monitoring test as an indicator of the amount of dirt on the skin.

The ATP hygiene monitoring test was conducted before and after the bed bath with the pressure sensor attached to the participant. First, the cotton ball part of the LuciPac® Pen was wetted with distilled water, and the wiping area (Fig 1) was then swabbed with it. Each wiping area was evenly swabbed with the entire cotton ball part of the LuciPac® Pen by rotating the cotton ball while swabbing. We swabbed the wiping area 15 times evenly in each of the longitudinal and lateral directions, but wiped the same area once. As mentioned above, the ATP hygiene monitoring test was performed by the same experimenter each time so that the procedure would be consistent.

4. Statistical Analysis

We performed an analysis using Friedman's test to make a comparison with the RLU levels of the wiping areas before the bed bath. The Wilcoxon signed rank test was performed to compare the RLU level before and after the bed bath.

The RLU level and wiping pressure were logarithmically transformed by taking the natural logarithm ($\log_e$) so that the data followed a normal distribution. The reduction in RLU level by the bed bath was logarithmically transformed, after subtracting the RLU level after the bed bath from the RLU level before the bed bath. To examine the factors related to the reduction in RLU level by bed bath, we performed a Pearson's correlation analysis of the RLU level and wiping pressure. The reduction in RLU level by bed bath was defined as an objective variable, and we performed a single regression analysis. We used EZR (version 1.54) (Saitama Medical Center, Jichi Medical University, Saitama, Japan) for the analysis [23]. All *p*-values were two-tailed, and $P < 0.05$ was considered to indicate statistical significance.

5. Ethical considerations

The current study was not reviewed by an Ethics Committee. The current study was a non-invasive, basic experiment on a member of our research group. We obtained informed verbal consent from the study participant. We did not collect personally identifiable information in this experiment. There was no conflict of interest. We received advice about the research design and methodology from researchers who were not involved in the study.

Results

1. Comparison of RLU levels of wiping areas before bed bath

We conducted the experiment 10 times on each wiping area (A to D). Table 1 shows the results of Friedman's test of the RLU level at each wiping area before the bed bath. There were no significant differences in the RLU levels of the different wiping areas. Thus, the subsequent analysis did not distinguish between the wiping areas.

Table 1: Results of Friedman's test of RLU level of wiping areas before bed bath

Wiping area	n	Mean (SD)
A	10	22,818.5 (16,723.0)
B	10	23,571.6 (15,760.1)
C	10	18,025.2 (9,961.1)
D	10	23,832.1 (11,530.4)
	Chi-squared	5.04
	df	3
	p-value	0.17

Table abbreviations
n: number of repetitions of the experiment at each wiping area
RLU: relative light units
SD: standard deviation
df: degrees of freedom

2. Factors related to RLU level reduced by bed bath

Table 2 shows data for the measured RLU level and wiping pressure, with the original measured value and the logarithmically transformed value with a natural logarithm ($\log_e$). Without distinguishing the wiping area, there was a total of 40 repetitions of the experiment. The RLU level was reduced by 72.6% ± 8.8% after the bed bath compared with the original RLU level value before the bed bath. The Wilcoxon signed rank test was performed to compare the RLU level before and after the bed bath, and the RLU level after the bed bath was significantly decreased compared with that before the bed bath ($P < 0.001$).

Table 2: Data for measured RLU level and wiping pressure

Original measured value			
	Mean (SD)	Minimum	Maximum
RLU level before bed bath	22,061.9 (13,459.1)	6,169	60,154
RLU level after bed bath	6,020.3 (4,255.6)	1,518	19,388
Reduction in RLU level by bed bath	16,041.6 (9,945.5)	3,856	47,261
Wiping pressure (g)	89.1 (81.2)	13.7	268.6
Logarithmically transformed values of the original data with natural logarithm ($\log_e$)			
	Mean (SD)	Minimum	Maximum
RLU level before bed bath	9.8 (0.6)	8.7	11.0
RLU level after bed bath	8.5 (0.7)	7.3	9.9
Reduction in RLU level by bed bath	9.5 (0.6)	8.3	10.8
Wiping pressure (g)	4.1 (0.9)	2.6	5.6

Without distinguishing the wiping area, there was a total of 40 repetitions of the experiment.
Table abbreviations
RLU: relative light units
SD: standard deviation
g: gram

The correlation analysis of the RLU level before and after the bed bath ($\log_e$) revealed a value of r = 0.87 (P < 0.001), indicating a strong and significant correlation (Table 3). Therefore, in the subsequent analysis, we focused on the relationships between the reduction in RLU level by bed bath, the RLU level before bed bath, and wiping pressure.

The correlation analysis between the reduction in RLU level by bed bath ($\log_e$) and the RLU level before the bed bath ($\log_e$) revealed a value of r = 0.99 (P < 0.001), indicating a strong and significant correlation (Table 3). The correlation analysis between the reduction in RLU level by bed bath ($\log_e$) and the wiping pressure ($\log_e$) revealed a value of r = −0.04 (P = 0.79), indicating no significant correlation (Table 3).

Table 3: Pearson's correlation analysis of RLU level and wiping pressure

	RLU level before bed bath ($\log_e$)	Wiping pressure ($\log_e$)
RLU level after bed bath ($\log_e$)	0.87 (P < 0.001)	–
Reduction in RLU level by bed bath ($\log_e$)	0.99 (P < 0.001)	0.004 (P = 0.79)

The correlation between the reduction in RLU level by the bed bath and the RLU level before the bed bath was strong and significant. We performed a single regression analysis in which the reduction in RLU level by the bed bath was defined as an objective variable and the RLU level before the bed bath was defined as an explanatory variable (Table 4). There was a significant relationship between the reduction in RLU level by bed bath and the RLU level before the bed bath, and the regression coefficient was β = 0.98 (P < 0.001). The adjusted coefficient of determination was $R^2 = 0.96$, which is considered to be high.

Table 4: Single regression analysis of reduction in RLU level by bed bath with RLU level before bed bath

Standardized regression coefficient (β)	Regression coefficient (B)	95% confidence interval	*P*-value
0.98	1.01	0.94–1.08	< 0.001
Adjusted $R^2 = 0.96$			

Table abbreviations
RLU: relative light units

Discussion

In the current study, there was no significant correlation between the RLU level reduced by bed bath and the wiping pressure (r = −0.04; P = 0.79). The ATP hygiene monitoring test revealed no clear relationship between wiping pressure and the amount of dirt removed or the hygiene of the skin. However, a significant correlation was found between the reduction in RLU level by bed bath and the RLU level before the bed bath (r = 0.99; P < 0.001; regression coefficient: β = 0.98; P < 0.001). Our analysis suggested that when the RLU level before the bed bath was higher, the reduction in RLU level by the bed bath was larger. It is possible that the amount of dirt on the skin before the bed bath affected the amount of dirt removed from the skin by the bed bath.

The major factors related to friction are skin hydration, the properties of the wiping materials, and wiping pressure [5]. We hypothesized that wiping pressure affects the amount of dirt removed by the bed bath. However, the current findings did not indicate a clear relationship between wiping pressure and removing dirt from the skin during a bed bath with a damp all-cotton washcloth. These results suggest the possibility that factors other than wiping pressure affect the friction on the skin, or that factors other than friction have an impact on the removal of dirt with a bed bath.

The defensive function of the skin protects the body from external physical, chemical, and microbiological stimuli [24]. Mechanical stimulation and excessive friction can damage the skin. The current results indicated that the RLU level after the bed bath was significantly decreased compared with that before the bed bath, but no significant relationship between the amount of dirt removed by the bed bath and wiping pressure was found, and the regression coefficient of the wiping pressure in relation to the amount of dirt removed by the bed bath was low. This finding further suggests the possibility that dirt can be removed and hygiene can be maintained regardless of the wiping pressure during the bed bath with a damp all-cotton washcloth. This finding may be useful for informing the future development of bed bath techniques that reduce the friction on the skin to protect the skin and still remove dirt. Because the current study did not examine the relationship between wiping pressure and defensive function or impairment of the skin, further study is required to clarify this issue in more depth.

Moreover, a previous study suggested that wiping pressure has an impact on the feeling that dirt has been removed from the skin [25]. Thus, wiping pressure may also be related to psychological aspects of satisfaction with a bed bath. It will also be necessary to consider the appropriate wiping pressure from the perspective of subjective feelings in future studies.

In the current study the RLU level exhibited substantial variation. Because the method used for measuring RLU levels differed among previous studies, it is difficult to simply compare the values of the RLU level with previous findings. However, previous studies that used the Kikkoman Lumitester device reported a high degree of variability of the RLU level among individuals. In two studies, the RLU level on the palms before hand washing exhibited substantial variability, with an RLU level of 2,395 ± 4,398 in one study [9], and an RLU level ($\log_e$) value of 4.3–5.0 in the other study [10]. In the current study, we controlled conditions such as room temperature, humidity, and the wiping material, and tested only one participant to minimize the effects of individual differences. However, in the current study the RLU level before the bed bath showed substantial variability, 22,061.9 ± 13,459.1 (in $\log_e$ 9.8 ± 0.6). Because ATP is contained in all organic matter [13, 14], dirt on the skin, which was measured as the RLU level, contains desquamated corneocytes, and microorganisms. The amount of dirt is affected by numerous factors including humidity, temperature, sudation, and clothing. Therefore, it is possible that the RLU level exhibited substantial variation, even in individuals, because of changes in the amount of the corneocytes, microorganisms, and other organic matter.

According to standardized values for the hands and fingers in the ATP hygiene monitoring test, an

RLU level of 3,000 is too high, whereas an RLU level of 1,500 is acceptable [21]. In the current study, the mean value of the RLU level after the bed bath was 6,020.3, which is considered to be sufficiently high even though the tested area was different. Although bed bathing removes bacteria and sebum, one study reported that showering has more impact on removing bacteria and sebum than bed baths [26]. Another study that measured ATP reported a lower RLU level after conventional bathing compared with a bed bath, although the difference was not significant [27]. However, the RLU level after the bed bath was significantly decreased compared with that before the bed bath. It shows that the dirt on the skin could be reduced by bed bath.

Moreover, in the current study, the reduction in RLU level by bed bath was 72.6 ± 8.8, whereas that reported in a previous study was 81.3 ± 8.4% [28]. This smaller reduction in RLU level by bed bath in the current study compared with the previous study might have been caused by a difference in the wiping method. In the current study, we wiped only once, with no overlap on the wiping area. In the previous study, the forearm skin was wiped back-and-forth evenly five times. Therefore, it may be necessary to examine the appropriate number of wipes to maintain hygiene when considering bed bath techniques in future studies. One previous study reported that bed bath with soap led to a higher rate of removal of ATP, although the difference was not significant [28]. Other studies have suggested that the remaining ATP after bed bath differs depending on the wiping material [29], and that more dirt might be removed by changing the side of the washcloth [30]. To maximize hygiene in bed bathing techniques, it will be necessary to examine factors that might have an impact on the removal of dirt by wiping other than wiping pressure, such as the number of wipes and the wiping material.

In the current study involved three major limitations. First, because the wiping pressure in the current study was between 13.7–268.6 g, the impact of wiping pressure outside of this range on removing dirt and maintaining hygiene could not be examined. Furthermore, the pressure sensor system used in the current study did not measure the wiping pressure as part of actual clinical care. Thus, the clinical validity of the measured wiping pressure in the current study could not be verified. However, the bed bath procedure was performed by an experimenter who was educated in and had practiced the bed bath procedure. Thus, we considered that the wiping procedure and technique were not substantially different from those in a clinical situation. Second, we used an all-cotton washcloth. We did not examine the relationship between wiping pressure and hygiene of the skin using other wiping materials. Moreover, the surface characteristics of the wiping material might affect removal of dirt with the bed bath. It will be necessary to conduct further studies of wiping materials with different surface characteristics, such as different pile shapes or heights. Third, the study participant was a healthy woman in her twenties who took a bath independently every day. Thus, the results may not be generalizable because of the small sample size. Additionally, the results cannot be directly applied to individuals who cannot maintain hygiene independently, such as bed-ridden patients, or those of different ages, such as children and older people. Therefore, it will be necessary to conduct studies with more cases in future

research. However, the results of the current study might provide useful basic information for future research in these patient populations.

Conclusion

The current findings did not indicate a clear relationship between wiping pressure and removing dirt from the skin during a bed bath with a damp all-cotton washcloth. The results suggest the possibility that dirt can be removed and hygiene can be maintained regardless of the wiping pressure. This finding might be useful for informing future research into bed bath techniques that reduce the amount of friction applied to protect the skin while removing dirt effectively.

Acknowledgments

We thank Benjamin Knight, MSc., from Edanz (https://jp.edanz.com/ac) for editing a draft of this manuscript.

References

1) Sheppard CM and Brenner PS. The effects of bathing and skin care practices on skin quality and satisfaction with an innovative product. Journal of Gerontological Nursing 26(10): 36-45, 2000.
2) Feo R and Kitson A. Promoting patient-centred fundamental care in acute healthcare systems. International Journal of Nursing Studies 57: 1-11, 2016.
3) Downey L and Lloyd H. Bed bathing patients in hospital. Nursing Standard 22(34): 35-40, 2008.
4) Nøddeskou LH, Hemmingsen LE and Hørdam B. Elderly patients' and nurses' assessment of traditional bed bath compared to prepacked single units-randomised controlled trial. Scandinavian Journal of Caring Sciences 29(2): 347-52, 2015.
5) Derler S and Gerhardt LC. Tribology of Skin: Review and Analysis of Experimental Results for the Friction Coefficient of Human Skin. Tribology Letters 45(1): 1-27, 2011
6) Veje PL, Chen M, Jensen CS, et al. Effectiveness of two bed bath methods in removing microorganisms from hospitalized patients: A prospective randomized crossover study. American Journal of Infection Control 48(6): 638-643, 2020.
7) Schoonhoven L, van Gaal BG, Teerenstra S, et al. Cost-consequence analysis of "washing without water" for nursing home residents: a cluster randomized trial. International Journal of Nursing Studies 52(1): 112-120, 2015.
8) Konya I, Yamaguchi S, Sugimura N, et al. Effects of differences in wiping pressure applied by nurses during daily bed baths on skin barrier function, cleanliness, and subjective evaluations. Japan Journal of Nursing Science 17(3): 1-13, 2020.
9) Yamada C, Shumiya T, Fukami S, et al. Effectiveness of Sanitary Education with the ATP Wipe Test and Scrubbing Checker. Journal of the Japanese Association of Rural Medicine 58(1): 46-49,

2009. (in Japanese)

10) Kuda T, Ota M and Kakinohana S. Clinical Significance of Surgical Hand Washing Evaluation Based on Adenosine Triphosphate Measurement. Japanese Journal of Infection Prevention and Control 26(2): 83-86, 2011. (in Japanese)
11) Likitlersuang J, Leineweber MJ and Andrysek J. Evaluating and improving the performance of thin film force sensors within body and device interfaces. Medical engineering & physics 48: 206-211, 2017.
12) Tang KPM, Yick KL and Li PL. Effect of Contacting Surface on the Performance of Thin-Film Force and Pressure Sensors. Sensors (Basel) 20(23): 1-20, 2020.
13) Sakakibara T, Murakami S, Eisaki N, et al. An enzymatic cycling method using pyruvate orthophosphate dikinase and firefly luciferase for the simultaneous determination of ATP and AMP (RNA). Analytical Biochemistry 268(1): 94-101, 1999.
14) Bakke M and Suzuki S. Development of a Novel Hygiene Monitoring System Based on the Detection of Total Adenylate (ATP+ADP+AMP). Journal of Food Protection 81(5): 729-737, 2018.
15) Sakakibara T, Murakami S and Imai K. Enumeration of bacterial cell numbers by amplified firefly bioluminescence without cultivation. Analytical Biochemistry 312(1): 48-56, 2003.
16) Thore A, Anséhn S and Lundin A. Detection of bacteriuria by luciferase assay of adenosine triphosphate. Journal of Clinical Microbiology 1(1): 1-8, 1975.
17) Ishimaru M, Noda H, Matsumoto E, et al. Comparative study of rapid ATP bioluminescence assay and conventional plate count method for development of rapid disinfecting activity test. The Journal of Biological and Chemical Luminescence 36(3): 826-833, 2021.
18) Lewis T, Griffith C, Gallo M, et al. modified ATP benchmark for evaluating the cleaning of some hospital environmental surfaces. Journal of Hospital Infection 69(2): 156-163, 2008.
19) Mildenhall KB and Rankin SA. Implications of Adenylate Metabolism in Hygiene Assessment: A Review. Journal of Food Protection 83(9): 1619-1631, 2020.
20) Okada J, Yamamizu Y and Fukai K. Effectiveness of hand hygiene depends on the patient's health condition and care environment. Japan Journal of Nursing Science 13(4): 413-423, 2016.
21) Kikkoman Biochemifa Company. Lumitester PD-20/PD-30 and LuciPac® Pen. (online)
Available from:
https://www.bio-strategy.com/site/bio-strategy-nz/files/Supplier_Subs/RBIO_Lumitester_Examples_0319.pdf (access date: 2022 September 19)
22) Hattori N, Sakakibara T, Igarashi T, et al. Rapid Measurement of Biological Contamination Using ATP-Bioluminescence Method. Journal of Japan Air Cleaning Association 38(5): 328-333, 2001. (in Japanese)
23) Kanda Y. Investigation of the freely available easy-to-use software ‘EZR’ for medical statistics. Bone Marrow Transplantation 48: 452-458, 2013.

24) Nguyen AV and Soulika AM. The Dynamics of the Skin's Immune System. International Journal of Molecular Sciences 20(8): 2-53, 2019.
25) Konya I, Nishiya K and Yano R. Effectiveness of bed bath methods for skin integrity, skin cleanliness and comfort enhancement in adults: A systematic review. Nursing Open 16: 1-17, 2021.
26) Shishido I and Yano R. Integrative Literature Review on “Bed Bath”. Japanese Journal of Nursing Art and Science 15(2): 172-182, 2016. (in Japanese)
27) Hashimoto M and Saeki Y. The Effects of Bed Bath on Stratum Corneum Hydration, Skin Lipid, Skin Surface pH and ATP Bioluminescence – In Comparison with Tub Bath in Healthy Females -. Japanese Journal of Nursing Art and Science 2(1):61-68, 2003. (in Japanese)
28) Kojima E, Fujinaga S and Kusanagi M. The Effects of Different Types of Bed Baths on Skin Surface pH, Skin Cleanliness, and Subjective Evaluations. Japanese Journal of Nursing Art and Science 17: 43-50, 2018. (in Japanese)
29) Amauchi M, Soman K, Hirata S, et al. Study of wiping, transferring and oozing of three kinds of wipes (materials) by evaluating ATP. Journal of Healthcae-associated Infection 9(2): 42-51, 2016. (in Japanese)
30) Nishiya K, Konya I, Shishido I, et al. Comparison of Dirt Removal Rate, Skin Temperature and Subjective Evaluations with or without Alternating Surfaces of Bed Bath Towels. Japanese Journal of Nursing Art and Science 20: 40-46, 2021. (in Japanese)