



## Evaluation of skin temperature, humidity, and comfort of two types of absorbent products for urinary incontinence

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### Abstract

Urinary incontinence is a major health problem affecting elderly people. Patients suffering from urinary incontinence frequently use adult diapers and absorbent incontinence pads. In recent years, mesh briefs have become widely used as an alternative to diapers in combination with incontinence pads; however, the functionality and comfort of mesh briefs have not been fully evaluated. The evaluation of incontinence products used on a daily basis is very important for elderly people. The present study aimed to clarify whether the use of a combination of mesh briefs and an incontinence pad is more comfortable than the use of diapers and an incontinence pad through the evaluation of both objective and subjective parameters. Six healthy women were recruited and randomly assigned to a diaper group or mesh brief group. Skin temperature and humidity at coccygeal, suprapubic, and left iliac regions were measured using special sensors and subjective discomfort was assessed using the VAS. The Wilcoxon signed-rank test was used to compare the two groups. After 60 minutes, skin humidity at the left iliac region tended to be lower in the mesh brief group than that in the diaper group ( $p=0.063$ ); however, no significant differences between the two groups were observed for the other regions. Subjective scores for "poor fit," "a sense of discomfort", and "difficulty moving" were significantly lower in the mesh brief group (each  $p=0.031$ ). These findings suggest that the use of mesh briefs in combination with insert pads may maintain subjective and objective comfort in users, possibly contributing to improved QOL.

Key Words : mesh briefs, diaper, incontinence pad, skin temperature, skin humidity

### Introduction

Urinary incontinence is a major health problem mostly affecting older people. The International Continence

Society defines urinary incontinence as "the complaint of any involuntary leakage of urine"<sup>1)</sup>. A multi-hospital survey in Japan reported that the prevalence of urinary incontinence was 72% in patients aged  $\geq 65$

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years<sup>2)</sup>, while the prevalence of urinary incontinence in hospital settings in the United States has been reported to be 10.5-43%<sup>3)</sup>.

Although a priority should be placed on the prevention and treatment of urinary incontinence, the evaluation of incontinence products used on a daily basis is also very important for elderly people. In Japan, 56% of elderly people ( $\geq 65$  years of age) receiving home care use adult diapers<sup>4)</sup>. Absorbent incontinence pads for urinary incontinence are also frequently used together with adult disposable diapers in both general hospitals and home care in Japan<sup>2)</sup>. Various types of incontinence absorbent pads have been developed and are commercially available. However, the combined use of multiple layers of diapers and pads raises concerns about increased interface pressure and humidity in the gluteal region<sup>5)</sup>, which can result in skin lesions. Ihara et al. reported that volunteer nurses noted "stiffness" when wearing multiple layers of diapers and pads<sup>6)</sup>. Discomfort as well as skin damage can negatively impact the quality of life of the elderly. Thus, it is important to prevent excessive skin humidity in regions covered by incontinence pads or diapers.

In recent years, mesh briefs have become widely used as an alternative to diapers in combination with incontinence pads, as mesh briefs have better air permeability and elasticity and hold incontinence pads in the gluteal region more effectively than diapers<sup>7)</sup>. Although mesh briefs are expected to be able to provide a more comfortable gluteal environment, the functionality and comfort of mesh briefs have not been fully evaluated.

Skin temperature and humidity are objective parameters that can be used to evaluate the comfort of the gluteal environment. A previous study<sup>8)</sup> reported skin humidity was more than 10% lower in a stroke patient using mesh briefs than that of conventional diapers. However, this result is difficult to generalize, because it was a report of a single case, and the measurement conditions were unclear. Furthermore, it is necessary to evaluate the comfort of diapers and mesh briefs both objectively and subjectively, especially from the user's viewpoint. It should also be taken into consideration that skin temperature

and humidity can be influenced by personal factors. We therefore aimed to investigate to what extent absorbent products influence temperature and humidity in a controlled environment free from the influence of personal factors.

The present study aimed to clarify whether the use of a combination of mesh briefs and an incontinence pad is more comfortable than the use of diapers and an incontinence pad by evaluating of both objective parameters and subjective assessments by healthy female volunteers. Additionally, we considered that it is important to verify air permeability of an incontinence pad, diaper, or mesh briefs in a similar experimentally controlled circumstance. By this verification, we may be able to evaluate more precisely whether the incontinence products themselves are effective in controlling skin temperature and humidity without personal factors. We thus investigated the relationship between the environment beneath the diaper or mesh briefs and temperature and humidity in a simple experimental study using laboratory glassware.

## Subjects and Methods

### 1. Experiment in healthy subjects

#### 1) Subjects

Six healthy women over the age of 20 were recruited by opportunistic sampling for this study. Women with skin disorders on the buttocks or who were currently menstruating were excluded. The study was carried out between January and April 2011.

#### 2) Study design

The study design was a randomized crossover trial. Subjects were randomly assigned to wear a disposable diaper with an incontinence pad (diaper group) or mesh briefs with an incontinence pad (mesh brief group). The incontinence products used in this study are shown in **Fig. 1**. Koyo Mesh Holder mesh briefs (Koyo, Yokohama, Japan), Takecare disposable diapers (Daio Paper Corporation, Tokyo, Japan), and Atento incontinence pads (Daio Paper Corporation, Tokyo, Japan) were used.

#### 3) Data collection

Demographic characteristics (age, height, and weight) were collected by a single researcher. Temperature and humidity of the skin covered by

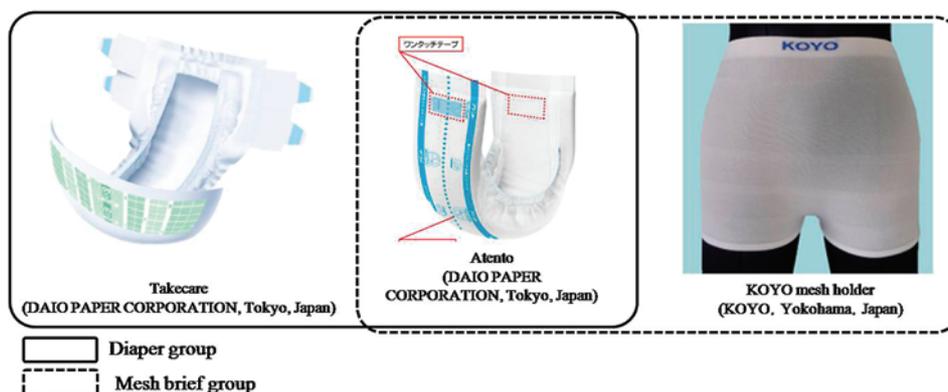


Fig. 1 Incontinence products

the disposable diapers or mesh briefs and subjective perception outcomes related to discomfort (stiffness, displacement of the pad, twisting of the pad, poor fit, sense of discomfort, and difficulty moving<sup>6)</sup>) were evaluated.

A skin temperature and humidity sensor (TSDL-HT2, Techno Science, Tokyo, Japan) was used to measure skin temperature and humidity on the buttocks<sup>9)</sup>. The measurement ranges of skin temperature and humidity for this instrument were -40.0-85.0 °C and 0.0-100.0% relative humidity (RH), respectively; measurement resolutions were 0.01 °C and 0.01% RH; and measurement accuracies were  $\pm 0.5$  °C and  $\pm 3\%$  RH. Skin temperature and humidity were measured at three points where pressure ulcers often form: coccygeal, suprapubic, and left iliac regions.

The magnitude of subjective discomfort (stiffness, displacement of the pad, twisting of the pad, poor fit, sense of discomfort, and difficulty moving) were measured using the Visual Analogue Scale (VAS). The maximum score was 10, indicating the worst state.

#### 4) Experimental protocol

Room temperature was set at 21-26 °C and humidity was maintained at 30-40% RH. The experiment was conducted from 9:00 to 18:00. Sheets were not used. Subjects used a cotton blanket. Subjects were requested to not eat at least 1 hour before the start of measurements, to discharge urine in advance, and to avoid voluntary movement and sleeping during the survey. Subjects wore 100% cotton nightwear.

First, in order to standardize the measurement conditions, the researcher explained the regions where

sensors were to be attached and how to wear the disposable diaper or mesh briefs and the incontinence pad. Sensors were then attached with silicon medical tape (Mepitac<sup>®</sup>, Mölnlycke Healthcare, Göteborg, Sweden) on the coccygeal region, suprapubic region, and left iliac region by the subjects. Subjects were instructed to lie in a supine position on a urethane mattress without sheets for 70 minutes, and skin temperature and humidity were measured over time. Skin temperature and humidity recorded after 10 minutes of bed rest were used as reference values for equilibration (Fig. 2); skin temperature and humidity were subsequently measured every minute for 60 minutes. The measurement time was limited to 60 minutes because some subjects experienced pain on their hip in the preliminary test. After skin temperature and humidity measurements, subjects were asked to answer the VAS to assess subjective discomfort perception.

After a three hour interval, subjects were requested to wear another set of absorbent products. Skin temperature and humidity were measured, and discomfort was evaluated by the VAS as described above.

#### 5) Data analysis

Skin temperature and humidity were evaluated using relative values at 60 minutes standardized by reference values. Measurements at 60 minutes were used for statistical analysis, as values gradually changed over time and changes were most apparent at 60 minutes. The Wilcoxon signed-rank test was used to compare skin temperature and humidity values in diaper and mesh brief groups after 60 minutes.

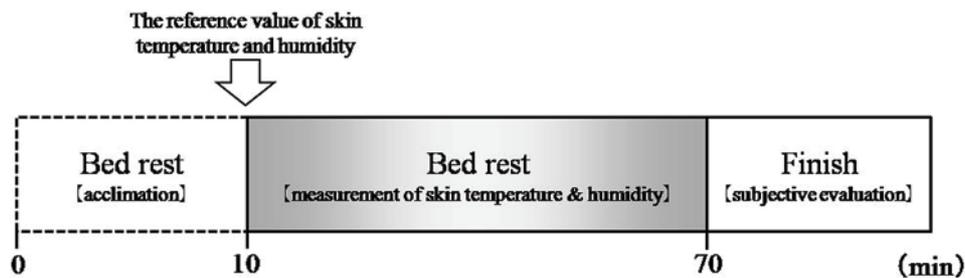


Fig. 2 Experimental protocol

A participant lay on the mattress. The first 10 minutes was the time allotted for acclimation. After 10 minutes, we measured changes in skin temperature and humidity in the participant. The participant evaluated the incontinence product with a subjective score.

Subjective perceptions were analyzed using the Wilcoxon signed-rank test.

All statistical analyses were performed using Statistical Analysis System ver. 9.2 (SAS Institute, Inc., Cary, NC, USA). A P-value less than 0.05 was considered to be significant.

## 2. Experiment using laboratory glassware

### 1) Study design

This was an experimental study.

### 2) Experimental protocol

In this experiment, temperature and humidity were measured in beakers covered by either a disposable diaper or mesh briefs. A small beaker (height, 7 cm; capacity, 100 mL) was placed upside-down within a large beaker (1 L). Two hundred and fifty milliliters of hot water at a temperature of about 48°C was added to the large beaker. A sensor was attached with tape to the bottom of the small beaker. The 1-L beaker was then capped with an incontinence pad, and was then covered with either a disposable diaper or mesh briefs. The large beaker and incontinence products were fixed in place with a rubber band (Fig. 3). Both sets of beakers (diaper and mesh briefs) were placed in an incubator set at 37°C. After a 30-minute stabilization period, data were collected for 60 minutes. Measurements were repeated three times at intervals of at least 30 minutes.

### 3) Data analysis

Temperature and humidity in beakers were measured after the 30-minute stabilization period. Temperature and humidity at 30 minutes were regarded as reference values. Relative changes in temperature and humidity per minute were calculated

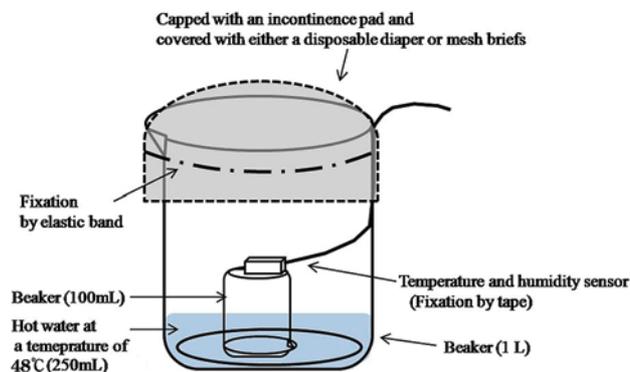


Fig. 3 Image of the glassware experiment with the temperature and humidity sensor

for 60 minutes.

## 3. Ethical considerations

The study protocol was approved by the Ethics Committee of the Graduate School of Medicine, The University of Tokyo, Japan. Written informed consent was obtained from all subjects.

## Results

### 1. Experiment in healthy subjects

#### 1) Participant characteristics

The mean age  $\pm$  standard deviation of subjects was  $34.8 \pm 6.6$  (range, 25-44) years. Body mass index (BMI) was  $19.2 \pm 1.2$  (range, 17.6-20.4). During the surveillance period, no skin damage caused by affixing the sensors on the body was reported.

#### 2) Objective measurements of skin temperature and humidity (Table 1)

Time-dependent changes in skin temperature and humidity in each region (coccygeal, suprapubic, and left iliac) were compared. Skin temperatures in both

**Table 1 Skin temperature and humidity relative values of the two groups after 60 minutes** (n=6)

Variable	Region	Diaper group	Mesh brief group	P value
Temperature				
	Coccygeal	1.04 (1.03-1.06)	1.04 (1.02-1.05)	0.688
	Pubic	1.02 (1.01-1.04)	1.01 (1.00-1.02)	0.250
	Left iliac	1.01 (1.00-1.01)	1.00 (1.00-1.02)	1.000
Humidity				
	Coccygeal	1.12 (0.70-1.27)	1.05 (1.01-1.17)	0.438
	Pubic	1.03 (0.66-1.09)	0.98 (0.87-1.08)	0.875
	Left iliac	1.03 (0.82-1.10)	0.96 (0.76-0.99)	0.063
Median (range) Wilcoxon signed-rank test				

**Table 2 Subjective evaluation** (n=6)

Item	Diaper group	Mesh brief group	P value
Stiffness	2.4 (0.0-8.7)	1.0 (0.0-5.7)	0.313
Displacement of the pad	1.9 (0.3-7.7)	0.3 (0.0-0.9)	0.063
Twisting of the pad	1.8 (0.2-7.8)	0.1 (0.0-1.7)	0.125
Poor fit	8.9 (6.2-10.0)	0.9 (0.2-2.2)	0.031
Sense of discomfort	7.5 (4.9-9.5)	2.0 (0.0-3.9)	0.031
Difficulty moving	6.4 (5.0-10.0)	1.9 (0.4-4.9)	0.031
Median (range), Wilcoxon signed-rank test A maximum score of 10, indicated the worst state			

the diaper group and the mesh brief group showed a similar increasing trend. In the diaper group, skin humidity in each region was higher than that of reference values, whereas in the mesh brief group, skin humidity in the suprapubic and left iliac regions was lower than that of reference values.

Statistical analysis of data obtained at 60 minutes revealed that skin humidity at the left iliac region tended to be lower in the mesh brief group than that in the diaper group ( $p=0.063$ ). No significant differences between the diaper group and mesh brief group were observed in the other regions.

### 3) Subjective discomfort (Table 2)

VAS scores for all items were lower in the mesh brief group than those in the diaper group. In particular, scores for “poor fit”, “sense of discomfort”, and “difficulty moving” were significantly lower in the mesh brief group (Each  $p=0.031$ ). Scores for “displacement of the pad” tended to be lower in the mesh brief group than those in the diaper group ( $p=0.063$ ). No significant

differences in the score for “stiffness” were observed between the two groups.

### 2. Experiment using laboratory glassware (Fig. 4)

The overall relative temperature of the beaker in the mesh brief group was lower than that in the diaper group for the entire 60-minute measurement period. However, the relative humidity of the beaker in the mesh brief group was similar to that in the diaper group at 60 minutes.

## Discussion

This is the first study to evaluate the usefulness and comfort of mesh briefs over disposable diapers using objective parameters such as skin temperature and humidity, as well as by subjective assessment using VAS scores for items such as stiffness, poor fit, and difficulty moving.

Relative values of skin temperature and humidity in the left iliac region tended to be lower in the mesh brief group than those in the diaper group at 60

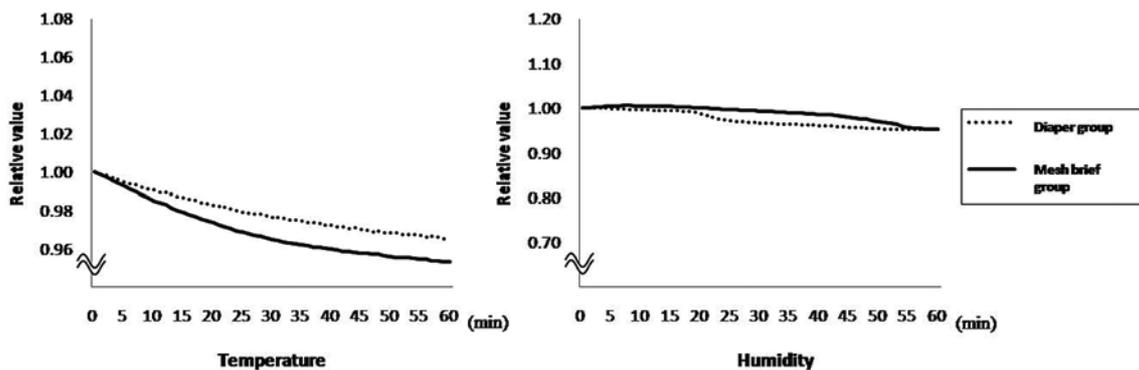


Fig. 4 Changes in relative temperature and humidity using laboratory glassware  
We measured the temperature and humidity in the beakers. Measurements were repeated three times.  
Median (n=3)

minutes after beginning measurements. However, no significant differences between the two groups were observed in coccygeal and suprapubic regions. These findings are different from a previous study by Tsuge et al.<sup>8)</sup>, who reported that skin humidity in a stroke patient using diapers was more than 10% higher than that of mesh briefs. These conflicting findings may be due to the fact that the patient reported by Tsuge et al. exhibited urinary incontinence<sup>8)</sup>, while the present study used healthy volunteers. We consider that the present study successfully evaluated the direct influence of incontinence products on skin temperature and humidity, regardless of the presence or absence of urinary incontinence. Moreover, as room temperature and humidity were controlled in this study, environmental effects were considered to have been minimized.

Results of the experiment using glassware suggest that there is no relationship between humidity and the type of garment (diaper or mesh briefs) used with the incontinence pad, even if the pad is permeable to air. In other words, skin humidity under the incontinence pad does not appear to be affected by the type of garment worn over the pad. This may be the reason why no significant difference was observed in the subjective evaluation of “stiffness” between the diaper group and mesh brief group. These findings suggest that the selection of incontinence pads may be more important than the selection of diapers or mesh briefs for controlling stiffness in the area covered by the pad.

In contrast, skin humidity in the left iliac region was

lower in the mesh brief group than that in the diaper group. Mesh briefs thus appear to more effectively control skin humidity than diapers. This point may be important in the prevention of pressure ulcers, which often form in humid iliac regions<sup>10)</sup>.

In Japan, many bedridden elderly people use incontinence pads together with diapers due to financial reasons and to facilitate changing. A previous study suggested that peak pressure in the gluteal region was significantly increased when the thickness of layered diapers and other absorbent products increased<sup>5)</sup>. Although mesh briefs are thin, economical, and effective in reducing temperature and humidity, they are less likely to be used generally. However, it is easy for caregivers to change the incontinence pads of bedridden elderly people because mesh briefs are elastic. A previous study pointed out that one of the disadvantages of mesh briefs is more frequent laundry due to higher nighttime incontinence leakage than that of diapers<sup>11)</sup>. However, Tsuge et al. reported that urinary leakage from mesh briefs can be prevented by appropriately selecting and applying incontinence pads<sup>8)</sup>.

The VAS scores for “displacement of the pad”, “poor fit”, “sense of discomfort”, and “difficulty moving” were significantly lower or tended to be lower in the mesh brief group than those in the diaper group. In other words, subjects perceived mesh briefs to be more comfortable than diapers. This result suggests that the form, design, and elasticity of the mesh briefs used in this study were similar to shorts for daily use by volunteers. In particular, mesh briefs are thinner, more

flexible, and have a better fit than diapers, possibly contributing to the better subjective assessments for “sense of discomfort” and “difficulty moving.” Furthermore, mesh briefs are less expensive than diapers<sup>11)</sup>, suggesting a reduced economic burden for users. Taking these findings together, we propose the use of mesh briefs as one way to improve the quality of life of the elderly.

The present findings should be interpreted in light of several potential limitations. Because study subjects were healthy adult women in their twenties to forties, care must be taken when generalizing this data to other populations. In addition, unlike the clinical setting, incontinence pads remained dry in the present study. Properties of aged skin, such as damaged barrier function, should be also taken into account in future studies.

### Conclusion

In the present study, we estimated the comfort of mesh briefs using subjective and objective evaluations, and obtained the following findings:

1. For objective parameters, temperature and humidity of the skin area covered with incontinence pads may not be significantly affected by the type of garment worn over the pads.
2. Mesh briefs appear to control skin humidity in the iliac region more effectively than diapers.
3. For subjective assessment, the VAS scores for “displacement of the pad”, “poor fit”, “sense of discomfort”, and “difficulty moving” were lower in the mesh brief group than those in the diaper group.

In summary, the use of mesh briefs together with an incontinence pad may maintain a higher level of comfort for users, possibly contributing to improved quality of life.

### Conflict of interest

The authors state that no financial or personal relationships exist with other persons or organizations that may inappropriately influence our work. Incontinence products were provided by Koyo Corporation and Daio Paper Corporation. These companies did not play any role in the study

design, data collection, data analysis, or manuscript preparation.

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## 尿失禁用アウター内の皮膚温・湿度と快適性の評価

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### 要 旨

尿失禁は高齢者の健康問題の1つである。尿失禁を有する高齢者は失禁用品を日常的に使用する。特に紙オムツと尿とりパッドの併用は臨床現場で多く、体圧の上昇や蒸れの問題が懸念されている。近年ネットパンツがアウターとして使用されるようになってきた。しかしネットパンツの有用性については十分明らかではないため、幅広い使用にいたっていない。われわれはネットパンツの有用性を明らかにするため、客観的な皮膚温湿度、ならびに主観的な快適性を紙オムツと比較することにより評価した。研究デザインはクロスオーバー試験であり、ネットパンツと紙オムツを交互に着用した。6名の健常人の仰臥位時の殿部皮膚温湿度を経時的に測定するとともに、快適性に関するVASの評価も行った。皮膚温湿度は基準値に対する相対値で比較し、ウィルコクソンの符号付順位検定を用いて解析した。その結果、60分後の左腸骨部皮膚湿度の相対値は、紙オムツ群よりネットパンツ群で低い傾向にあった ( $P=0.063$ )。一方で尿とりパッドに覆われていた仙骨部と恥骨上部は皮膚温湿度ともに両群で差はなかった。VASの評価では、「フィット感のなさ」、「違和感」、「動きにくさ」の項目でネットパンツ群が有意に低値であり、快適に感じていた。本研究より失禁用品は尿とりパッドの選択が重要であり、さらにアウターとしてのネットパンツは主観的にも客観的にも快適であるため、患者のQOL向上に役立つ可能性が示唆された。

キーワード：ネットパンツ、紙オムツ、尿とりパッド、皮膚温、皮膚湿度