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INVESTIGATIVE REPORT

The Vulvar Skin Microenvironment: Impact of Tight-fitting Underwear on Microclimate, pH and Microflora

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The aim of the present study was to investigate if tight-fitting underwear (string panties) equipped with string panty liners affected the vulvar skin microenvironment differently to regular panties with standard panty liners. Thirty-two healthy women participated in a crossover study where temperature, humidity, surface pH and aerobic microflora were measured on vulvar skin. Vulvar skin temperature was 35.2±0.19 (mean±SEM) and 35.3±0.17°C, respectively, for the two underwear systems. Mean humidity and mean skin surface pH at vulvar skin did not differ between the two systems. Barely noticeable differences were found for the aerobic microflora both at labium majus and at perineum. The mean total number of microorganisms in the two different panty liners was the same, 6.0±0.15 and 6.0±0.16, respectively (log CFU per panty liner). The differences in panty and panty liner design studied seem to have negligible impact on the vulvar skin microclimate, skin surface pH and aerobic microflora. No support was found for the assumption that a string panty system would result in higher contamination of vulvar skin by anorectal microflora. ***Key words: clothing; hygiene absorbent products; panty liners; skin temperature; skin humidity; string panties; TEWL.***

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Many women today are using scantily-cut underwear, i.e. tanga and string panties (also called G-strings or thongs). This fashion is growing, especially among young women, and now constitutes 25% of the total US panty market (1). It has created a niche for sanitary protection products (primarily panty liners) adapted to fit closely to the crotch of the panties (Fig. 1). String panties are designed to be narrow enough to slip in between the buttocks enabling a closer fit to the body. It has been feared that this may cause a relatively warmer and more humid skin environment, even more so when the panties are used with sanitary protection liners. It is assumed that string panties might cause irritation as they rub against the mucosa. Another fear has been that the tight fit may render the wearer more prone to contamination of the vulvar microflora with micro-organisms from the anorectal area.

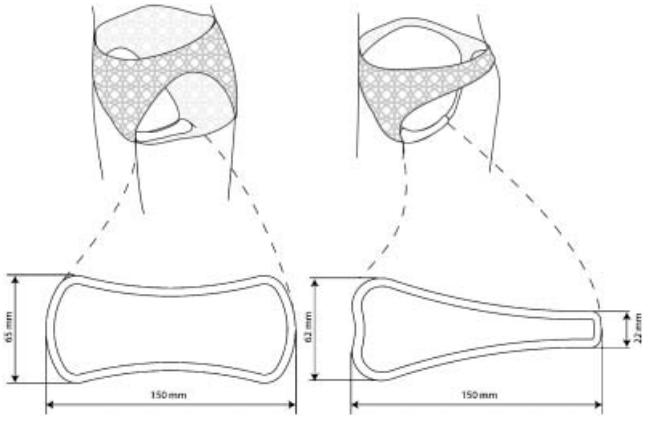

Fig. 1. Design of the panty and panty liners. Regular model to the left and string model to the right.

In an earlier study, we showed that non-breathable panty liners (i.e. products with water vapour-impermeable back sheets) significantly increased vulvar skin temperature, humidity and pH, compared with the use of either no panty liners at all or of panty liners with a breathable (water vapour-permeable) back sheet (2). In a second study we found that the number of aerobic microorganisms in the vulva was significantly higher with non-breathable panty liners than with no panty liners or breathable ones, although the risk of microbial infection was not considered much higher (3). Heidrich et al. (4) studied the associations of clothing factors and vulvovaginal symptoms. They found similar rates of vaginitis symptoms for women who wear or do not wear panty hose. However, yeast vaginitis was about three times more common among panty hose wearers. No relationship with vaginitis was found for other clothing factors, i.e. sleep underwear, cotton lining panels and pants vs skirts as outerwear. Elegbe & Botu (5) reported that women wearing loose-fitting clothing had lower carriage rates of *Candida albicans*. The belief that feminine itching and problems in the urogenital area are associated with tight-fitting clothing is widespread (6–9). Reed (7) concluded that very few data exist regarding the role of clothing types and sanitary

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protection on recurrent *Candida* infections. Avoidance of mechanical irritation (tight clothing), maceration and artificial irritants may be prudent until further information is available.

In the present study we measured the temperature of the vulvar skin, skin surface pH, humidity and the relevant aerobic microorganisms in a group of healthy women, on one occasion when they were using regular panties with standard panty liners (R) and on one when string panties with string panty liners (S) were worn. The purpose was to assess a possible difference between the two different garment types in terms of tightness of fit. Comparisons were made with our two previous studies (2, 3) in order to further elucidate the findings.

MATERIALS AND METHODS

Subjects

Thirty-two healthy, Caucasian, female volunteers (mean age 32.9 years, range 23–45) with regular menstruation participated. Subjects who had used antibiotics or vaginal medication <4 weeks prior to the study, or had current abnormal discharges, bleeding, itching or irritation in the vulvar area, were excluded. The study was approved by the local research ethics committee, and the subjects gave their written consent to inclusion.

Panties and panty liners

The two panties, Sloggi Tai (R) and Sloggi String (S) respectively, supplied by the same company (Triumph International AB, Stockholm, Sweden) and manufactured from the same cotton fabrics, differed only in design. The two panty liners, Libresse® Normal (R) and String (S) (SCA Hygiene Products, Sweden), were composed of identical materials and the only difference was the design as shown in Fig. 1. Both panty liners were of a standard specification with no extra functions such as pH adjustment or antimicrobial additives, except for water vapour-permeable back sheets (Exxaire XBF-110W, Tredegar Film Products, Kerkrade, The Netherlands. The water vapour permeability is 8600 g/m^2 per 24 h according to ASTM-F1249 (American Society for Testing and Materials).

Experimental design

The study was carried out from March to June of 2002. The design and methods have been described in detail in two earlier studies (2, 3). The subjects were randomly assigned in a crossover design so that half of the group started with each panty system. One subject was withdrawn from the second round of the test for non-test related reasons. In the clinic, the subjects had to rest for 15 min, lying down. First the temperature was measured without removing the panties. Then the panties and the panty liners were removed, and the pH was measured at the interior aspect of the labium majus and in the perineum. A sampling cylinder was then placed at the opposite site at the other labium majus, and the skin was gently 'scrubbed' with the detergent liquid for 1 min.

Skin temperature

The temperature was measured using an electronic thermometer MicroTherma 2T (Electronic Temperature Instruments Ltd, UK), equipped with a thermocouple microprobe (IT-18, Physitemp Instruments Inc., USA). Measuring resolution was ± 0.1℃. The probe was placed at the labium majus to correspond to the microbial sampling site at the opposite labium.

Skin surface wetness

An EP2 Evaporimeter (ServoMed, Varberg, Sweden) was used. The instrument is designed to measure the transepidermal water loss (TEWL) in g/m^2/h; however, in connection with the use of skin-occlusive products the instrument is utilized to assess the skin surface wetness (10, 11). Immediately after removing the panty liner, the probe was applied to the interior aspect of the labium majus. The values obtained were adjusted to a reference skin temperature of 30℃, using the formula developed by Mathias et al. (12): $\log TEWL_{30} = \log TEWL_T + 0.035\ (30 - T)$.

Vulvar skin microflora

A modification of the Williamson-Kligman scrub technique (13) was used to collect samples from the labium majus and perineal sites, and the samples were analysed as described in the previous study (3).

Statistics

For test of significance between the two systems (R vs S), Student's t-test was used for temperature, skin wetness and pH, and Wilcoxon's sign rank test for microbial data (logged CFU, means counted on positive values, Wilcoxon's test on all values). McNemar's test was used for subjective data (e.g. sensation of chafe).

RESULTS

Skin microclimate

The mean values and SEM for skin temperature, wetness and pH are presented in Table I. There was no significant difference between the two systems (R vs S) for any of the three skin climate variables. There were no subjectively experienced differences regarding feeling of warmth (four answers for R, five for S) or humidity (seven in both systems). However, when asked, 12 women had felt mechanical chafing after trying the string system, against 3 women after the regular one ($p \leqslant 0.001$). No visual signs of irritation or redness were observed on any occasion. Table II displays the correlation of climate variables between the two test occasions

Table I. *Mean values (SEM) of skin temperature (Temp), skin wetness ($TEWL_{30}$) and pH; comparisons between regular panty with regular panty liner (R) and string panty with string panty liner (S)*

Panty system	R (n=32)	S (n=31)
Temp (℃)	35.2 (0.19)	35.3 (0.17)
$TEWL_{30}$	50.5 (2.70)	50.6 (3.26)
pH (LM)	5.4 (0.12)	5.6 (0.15)
pH (PE)	5.6 (0.17)	5.5 (0.14)

LM, labium majus; PE, perineum.

Table II. *Correlation of climatic variables between regular panty/panty liner (R) and string panty/panty liner (S) (n=31)*

R vs S	Correlation (r)	*p* value
Temperature	0.078	0.677
$TEWL_{30}$	0.262	0.154
pH (LM)	0.608	<0.001
pH (PE)	0.505	0.004

TEWL, transepidermal water loss; LM, labium majus; PE, perineum.

(R vs S). The pH of both labium majus and perineum correlate significantly ($p \leqslant 0.001$ and $p \leqslant 0.01$).

Vulvar skin microflora

The results of the microbial analyses are shown in Table III. In 30 of 33 instances, there were no significant differences between the regular and the string panty system. In three instances there was a significant difference, all three at the lowest level ($p \leqslant 0.05$). For group B streptococci (perineum), the amount and the carriage rate were higher with the regular system. For *Corynebacterium* spp. (panty liners) and for lactobacilli (labium majus), the amount was higher with the string panty system.

DISCUSSION

The present study was the last of a series of three aiming to study the vulvar microenvironment in the same type of female populations. In the first study (2) ($n=12$) the microclimate (i.e. temperature and skin wetness) and the vulvar pH were measured, with and without different panty liners. In the second study (3) ($n=102$) the temperature, vulvar pH and aerobic microflora were measured, but not the skin wetness, for women without

Table III. *Positive samples (%; n=32 with regular, n=31 with string) and mean number of microorganisms for positive samples in labium majus (LM), perineum (PE) in log CFU/cm² skin, and in panty liner (PL) in log CFU/product*

		Type of panty and panty liner					
		Regular			String		
Microorganism group	Site	%	Mean	SEM	%	Mean	SEM
Staphylococcus aureus	LM	13	3.22	0.552	10	1.58	0.350
	PE	25	2.26	0.420	23	1.62	0.370
	PL	19	3.74	0.507	13	3.78	0.619
Coagulase-negative staphylococci	LM	100	4.35	0.110	100	4.14	0.124
	PE	97	3.77	0.148	100	3.99	0.122
	PL	100	4.87	0.141	100	5.13	0.148
Group B streptococci	LM	34	2.07	0.340	19	2.31	0.279
	PE	41	3.28	0.286	32	2.61	0.444*
	PL	34	3.51	0.296	26	3.93	0.351
α-Streptococci	LM	53	2.57	0.218	52	2.40	0.316
	PE	63	3.08	0.166	61	3.09	0.232
	PL	44	3.94	0.326	42	3.88	0.305
Corynebacterium spp.	LM	97	2.66	0.168	100	2.71	0.146
	PE	100	3.18	0.107	100	3.48	0.147
	PL	100	4.14	0.159	100	4.55	0.142*
Lactobacilli	LM	100	2.91	0.163	100	3.30	0.152*
	PE	100	3.52	0.185	100	3.73	0.146
	PL	97	4.93	0.218	100	5.16	0.203
Enterococci	LM	13	3.43	0.435	13	2.58	0.482
	PE	19	2.56	0.465	19	3.28	0.354
	PL	13	3.61	0.700	16	4.48	0.344
Escherichia coli	LM	9	1.43	0.834	19	1.61	0.367
	PE	41	2.31	0.321	45	1.71	0.274
	PL	9	3.38	0.612	23	4.12	0.426
Other Enterobacteriaceae	LM	0			3	0.28	
	PE	13	1.68	0.456	10	2.62	0.434
	PL	0			6	3.08	0.200
Candida albicans	LM	12	1.95	0.711	10	1.48	0.758
	PE	16	1.37	0.421	10	1.24	0.667
	PL	13	4.28	0.402	13	3.58	0.482
Total microorganisms	LM	100	4.80	0.109	100	4.70	0.107
	PE	100	4.84	0.083	100	4.84	0.096
	PL	100	6.01	0.154	100	6.00	0.161

Wilcoxon's signed rank test was used for test of significance (all values included).
*Significant difference between regular and string system, $p \leqslant 0.05$.

panty liners and with two types of panty liners (non-breathable vs breathable and acidic). In the present study the temperature was equal in the two panty/panty liner systems, but somewhat higher compared with the first study (2), for identical products. This may be due in part to a change of method. The earlier method (2, 3) measured the enclosed air temperature between the panty liner and the skin, with a disposable probe (no longer available on the market), while the present method measured the temperature at the labium majus skin with a thermocouple probe. Another difference between the first study (2) and the present one is that the skin wetness ($TEWL_{30}$) was this time measured at the interior aspect of the labium majus, while in the first study the measuring point was on the exterior aspect. This is probably the reason behind a lower value (41 vs 51 $g/m^2/h$) in the first study (2). The shift was made as it was considered of greater interest to study the microflora in the more humid part. The microflora sampling in the second study (3) was similarly performed at the interior aspect. The mean pH values differ a little between the three studies, and in the present study the perineum value was not always higher than the labium majus value, as might have been expected from the earlier studies. Variations between the three studies may of course also be due to differences in time and study populations.

Table II shows the correlation between the two test occasions for each climate variable. The r^2 value is used to explain the extent of the influence (14), which means that the variations in the pH results obtained can to 36% and 25% (labium majus and perineum, respectively) be explained by intra-individual (inherent) factors. This can be compared with only 6% explanation of the skin wetness (TEWL) and $<1\%$ explanation of the temperature attributed to inherent factors.

Regarding the microflora in the present study, the three significant differences ($p \leqslant 0.05$) found in comparison between the two systems are only what could be expected by pure chance (mass significance). The present study population was only 32 individuals (31 in the string system) so the results of the larger study (3) should be more representative. Still, comparison of the results of these two studies reveals many similarities, both in carriage rates and in number of microorganisms. Coagulase-negative staphylococci, *Corynebacterium* spp. and lactobacilli were found in all subjects. The carriage rate of *S. aureus*, reported by Aly et al. (15) as being as high as 67% for a similar study population, was 10–25% in this study, close to the results of our previous study (3). Similarly, only 10–16% had positive samples for *C. albicans* compared with 5–15% seen in the earlier study (3). In this study, as in the previous study, the carriage rate for *Escherichia coli* was much higher at the perineum than at the labium majus, at rates similar to those reported by others (15–17). The carriage rate for group B streptococci in this study was 19–41% compared with 20–38% in the previous one (3). Regarding α-streptococci, the rate in this study was 42–63% compared with 19–37% (3), and for enterococci the situation was the reverse, 13–19% in the present study, compared with 22–46%. This reverse situation could be explained by antagonistic behaviour between α-streptococci and enterococci, as was pointed out in the previous study (3). However, the present study provides no support for the antagonistic behaviour that has been assumed. The sample size may be too small to observe such an interaction.

In the present study, there was no difference between the two panty/panty liner systems in skin climate (temperature and wetness), skin surface pH or aerobic microflora. It should be emphasized that the two panty liners used in this study were both equipped with breathable back sheets. We know from earlier studies (2, 3) and reports from others (18–21) that a non-breathable plastic film will occlude the skin and may result in increased temperature, skin wetness, increased pH and a higher number of microorganisms. Our study of healthy women (where the carriage rate of *Candida* was rather low) is complemented by the findings of Rylander et al. (22) in that there was no significant association between frequent use of string panties and growth of *Candida* among young women with genital symptoms who consulted adolescent health centres. The reported higher incidence of chafing in the present study for the string panty/panty liner may not result from actual rubbing of the skin, as no visual signs were reported. For some women the string panty liner did not stay in place. When this happens, the subsequent discomfort may be reported as chafing. Nothing was found in this study to support the suggestion that a string-type panty system could result in higher contaminations of the vulvar skin with anorectal microflora than a comparable regular panty system. With underwear or panty liner design other than studied here, or with other users or habits, the outcome may have been different; therefore caution should be exercised in generalizing the results.

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