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INVESTIGATIVE REPORT

The Vulva Skin Microclimate: Influence of Panty Liners on Temperature, Humidity and pH

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Many women use panty liners between menstrual periods. The aim of this study was to investigate whether the use of such products might influence the vulva skin. Twelve healthy women were studied on four occasions with three different product constructions and on one occasion without products. Temperature, surface wetness and surface pH were measured on vulva skin. Mean skin temperature when the women were wearing a conventional panty liner (with a non-breathable back sheet) was 35.9°C, compared to 34.4°C when wearing no panty liner at all ($p < 0.01$) and 34.5°C when using a panty liner with a breathable (i.e. vapour permeable) back sheet ($p < 0.01$). Skin humidity was significantly higher when the conventional panty liner was used compared to no panty liner or to the breathable panty liner (both cases $p < 0.01$). The mean pH value at the exterior aspect of the *labium majus* was 5.8 with the conventional panty liner, 5.2 with no panty liner and 5.3 with the breathable panty liner ($p < 0.001$ and $p < 0.01$, respectively). The results indicate that the conventional panty liner changes the vulva skin microclimate, but that the breathable panty liner to a substantial degree keeps the microclimate at an undisturbed level. The actual effect of these differences on microbiological flora will be addressed in a subsequent study. *Key words: hygiene absorbent products; skin surface pH; skin surface wetness; skin temperature; vapour permeability.*

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The use of panty liners is increasing, with a growing number of women using protection between menstrual periods in order to feel safe and clean. It has been assumed that frequent use of liners might have a negative influence on the vulva skin, owing to the fact that constant cover could affect the temperature and humidity of the skin. Microclimate changes can influence the growth of fungi and bacteria.

Studies using non-invasive bioengineering skin technology have partially characterized the vulva skin as having unique properties, and that there may exist physiological differences in the *stratum corneum* between the vulva skin and the frequently studied forearm skin (1–4). One study investigating the frictional properties of forearm and vulva skin concluded that the high friction coefficient of vulva skin could be due to increased hydration (5).

A study by Aly et al. showed that prolonged occlusion of the forearm skin leads to increased bacterial growth and increased pH (6). Panty liners do not occlude the skin to the same extent as in that study, however, where the skin was tightly occluded with plastic film.

The use of so-called breathable, i.e. water vapour-permeable, materials has been introduced for clothing (e.g. Gortex® fabrics used in rainwear) and nowadays even for absorbent hygiene products such as diapers, feminine towels and panty liners. In a patent application (7), it has been shown under controlled 'laboratory' conditions that the use of sanitary napkins with breathable back sheets results in a lower vulva skin temperature compared to products with non-breathable back sheets.

In recently published articles, Akin et al. (8) and Schäfer et al. (9) show the effects of breathable materials on the skin. While Akin et al. show that disposable diapers with breathable back sheets result in a reduced prevalence of *Candida* and diaper dermatitis, Schäfer et al. conclude that hygiene products with vapour-permeable materials reduce skin over-hydration.

The aim of the present study was to investigate how panty liners influence the climate of the vulva skin (temperature, surface wetness and pH).

MATERIAL AND METHODS

Subjects

Twelve healthy, Caucasian, women volunteers (mean age 37; range 32–45) with regular menstruation participated in this exploratory study – each subject her own control. The women were asked about washing habits, their use of contraceptives, earlier yeast infections, skin diseases and use of hygiene products. Eleven of the 12 subjects had earlier experienced yeast infection (this was a coincidence; no selection was made). Subjects who had used antibiotics or vaginal medication less than 4 weeks prior to the study, or had current abnormal discharges or irritation in the vulva area, were excluded. The study was approved by the local research ethics committee, and the subjects gave their informed consent to inclusion.

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Panty liners

Three different panty liners (B, C and D) were evaluated and compared to the situation without panty liners (A). The liners were produced by the same company (SCA Hygiene Products, Sweden) and had as identical design and composition as possible. B was a conventional type liner with a non-breathable back sheet. C had a breathable back sheet (Exxaire XBF-110W, Tredegar Film Products, Kerkrade, The Netherlands. The water vapour permeability is 8600 g/m^2 24 h according to ASTM-F1249, American Society for Testing and Materials). D had a slightly thicker absorbent core and was acidified to pH 4.5 with a super absorbent polymer (HySorb S7110, BASF, Germany), and had a conventional non-breathable back sheet.

Experimental design

The subjects were carefully instructed (orally and in writing) on how to use the products and manage their hygiene. They were randomly assigned to the three different panty liners or no panty liner according to a pre-set random sequence so that all test variants were evenly distributed over the 5-month test period. This was to prevent possible bias due to climatic (and clothing) influence on the measurements. The differences between the panty liners were unknown to the subjects, who were instructed to use only water for genital washing and not to have sexual intercourse on the evening before the examination visit to the clinic. All participants were provided with panties of the same type.

The examination visit was planned for either the 16th or the 20th day of the menstrual cycle. Three days before the visit, the subjects had to begin to wear the panty liner provided. Recommended usage was two to three products during daytime and one product during night-time, but slight deviations were permitted. In the morning, after 3 days' use, the women had to apply a disposable thermistor probe between the panty liner and the skin before going to the clinic for measurements.

In the clinic, the subjects had to rest for 15 min, lying down. First the temperature was measured without removing the panties. The panties and liners were then removed and immediately the TEWL (transepidermal water loss) was measured at the exterior aspect of the upper part of the *labium majus* (the TEWLdirectly value). Measurement of the capacitance, temperature and pH at the same site then followed, always in that order. Capacitance and pH were measured in the fold between the *labia majus* and *minus* (the *interlabial* fold). Thereafter, the same measurements were repeated on the skin in the *perineum*. Finally, after approximately 15 min, the TEWL was again measured at the *labium majus* site. Before the test of each panty liner or the test without any panty liner, some participants had to gently trim the hair at the *labium majus* site with a pair of scissors. Shaving of the genital area was not permitted during the test. The measurements, including the 15-min resting period, took place in an ordinary investigation room (not air-conditioned). The whole study was carried out during February to early June.

Skin temperature

A Craftemp® thermometer system was used. The disposable probe had a sensor head of a heat-sensitive resistor accurate to $\pm 0.1^{\circ}$C, according to the manufacturer. The use of these measuring probes has been described by Karlsson et al. (10). Supplied by Astra Tech AB, Mölndal, Sweden, the device is unfortunately no longer available on the market. When measuring the temperature, the probe was fixed to the panty liner, or in case A to the panty, with a highly air-permeable self-adhesive fabric (Mefix®; Mölnlycke Health Care, Göteborg, Sweden). When directly measuring the temperature on the exterior aspect of the *labium majus*, the probe was positioned with the help of a cotton tip.

Skin surface wetness

An EP2 Evaporimeter (ServoMed, Varberg, Sweden) was used. The instrument is designed to measure the so-called TEWL in g m^{-2} h^{-1}, which is usually an indication of the status of the skin barrier. However, in connection with the use of skin-occlusive products the instrument is utilized to indicate skin surface wetness, as reported in the literature (11, 12). Immediately after removing the panty liner, the probe was applied to the exterior aspect of the *labium majus*. The *labium majus* was slightly pushed in order to get the sensoring-funnel of the probe, as far as possible, into a vertical position. The measurement was registered for 45 sec in a computer and the average of the last 15 sec was taken as the TEWL value. Detachable copper protection shields for the probe were sanitized in alcohol between subjects. As TEWL increases with increased skin temperature, the values obtained were adjusted to a reference skin temperature of 30°C using the formula: $\log \mathrm{TEWL}_{30} = \log \mathrm{TEWL}_{T} + 0.035\,(30 - T)$ (from ref 13).

Skin capacitance

The CM825 Corneometer (Courage+Khazaka, Cologne, Germany) was used to measure the electrical capacitance, which will vary with the moisture content of the *stratum corneum*. The readings are in arbitrary units, where 0 is very dry and above 100 is a level of high moisture (14). The probe was cleansed with alcohol between subjects.

Skin surface pH

The PH 900 pH meter (Courage+Khazaka, Cologne, Germany) was used with a Mettler-Toledo 304 flat electrode. The probe was cleansed with de-ionized water before each measurement and the last drops were kept on the electrode to provide a wet state on the skin during measurement. A waiting period of approximately 30 sec was maintained before the reading was recorded. Accuracy of the pH meter is 0.1 units. The instrument was calibrated each day with buffers of pH 4 and 7. Between subjects, the electrode was cleansed with alcohol.

Statistics

The 12 subjects were their own controls. Hence an ANOVA analysis for repeated measures was used to test significance between the different cases with a Statview® computer program. Because there is a risk of mass significance, the probability level of 5% should not be counted on, but rather the levels below 1%, according to Bonferroni (15).

RESULTS

The results of the measurements are presented in Table I and comparisons with the ANOVA test in Table II. The cases with no panty liner (A) and those with the panty liner with breathable back sheet (C) had a lower mean temperature, both on the skin covered by the panty liners and at the *labium majus*, than the

Table I. *Measurements of vulvar climate variables on 12 subjects using no panty liner or 3 different liners. Mean values ± SEM. A = no panty liner, B = non-breathable, C = breathable, D = acidified, non-breathable*

	A	B	C	D
Temp. prod/skin (°C)	34.4 ± 0.6	35.9 ± 0.3	34.5 ± 0.3	35.9 ± 0.2
Temp. *labium majus* (°C)	34.0 ± 0.2	35.0 ± 0.2	34.3 ± 0.1	34.7 ± 0.1
TEWL30directly[a] (g m^{-2} h^{-1})	41 ± 6	55 ± 5	41 ± 6	53 ± 4
TEWL30 after 15 min[b] (g m^{-2} h^{-1})	44 ± 3	43 ± 5	38 ± 6	52 ± 6
Cap.[c] *labium majus*	74 ± 10	77 ± 7	81 ± 9	73 ± 7
Cap.[c] *interlabial* fold	129 ± 2	126 ± 3	128 ± 3	133 ± 1
Cap.[c] *perineum*	127 ± 4	128 ± 3	127 ± 4	132 ± 3
pH *labium majus*	5.2 ± 0.1	5.8 ± 0.1	5.3 ± 0.1	5.4 ± 0.1
pH *interlabial* fold	5.5 ± 0.1	5.6 ± 0.1	5.5 ± 0.1	5.6 ± 0.1
pH *perineum*	5.6 ± 0.1	6.1 ± 0.1	5.9 ± 0.1	5.6 ± 0.2

[a]Two values were omitted (cases C and D), being extreme outliers (175 and 260). Adjusted to 30°C.
[b]One extreme value omitted (case A, 195). Adjusted to 30°C.
[c]Capacitance with the Corneometer, arbitrary units.

Table II. *Comparisons of the microclimate in vulva with ANOVA test for repeated measures. Mean differences are shown. A = no panty liner, B = non-breathable, C = breathable, D = acidified, non-breathable*

	B – A	C – A	D – A	B – C	D – C	B – D
Temp. prod/skin (°C)	1.55*	0.07	1.54*	1.48*	1.47**	0.01
Temp. *labium majus* (°C)	0.97**	0.24	0.62**	0.73**	0.38	0.35
TEWL30 directly (g m^{-2} h^{-1})	15*	0	12*	15*	12*	2
TEWL30 after 15 min (g m^{-2} h^{-1})	−1	−6	8	4	13	−9
Capacitance *labium majus*	4	7	−1	−3	−7	4
Capacitance *interlabial* fold	−2	−1	5	−1	6	−7
Capacitance *perineum*	1	1	6	1	5	−4
pH *labium majus*	0.63**	0.18	0.29	0.45*	0.11	0.34
pH *interlabial* fold	0.08	0.00	0.06	0.08	0.06	0.02
pH *perineum*	0.47*	0.28	0.00	0.19	−0.28	0.47*

*$p < 0.01$; **$p < 0.001$.

cases with non-breathable back sheets. The differences were significant at the 0.01 level in all cases except case C versus D, where p was 0.02 at the *labium majus* site.

The differences in skin surface wetness (TEWLdirectly) were significantly lower with no panty liner use and with the panty with breathable back sheet compared to when the two panty liners with non-breathable back sheets were used (all cases $p < 0.01$).

Capacitance differs significantly between one site (*labium majus*) and the other two sites (*interlabial* fold and *perineum*; $p < 0.001$). However, no significant differences were found between the different panty liners or the case without liner at any of the three sites.

At the *labium majus* site, the pH was significantly higher when the non-breathable panty liner was used compared to when no liner was used ($p < 0.001$) and when the breathable panty liner was used ($p < 0.01$). At the *perineum* site, the pH was significantly higher for the non-breathable panty liner compared to when no liner was used ($p < 0.01$). When comparing the two panty liners with non-breathable back sheets, the one with the acidified core gave a lower skin pH at the *labium majus* and the *perineum* sites ($p = 0.02$ and $p < 0.01$).

An erythematous vulva was seen on two occasions (cases A and D). The subjects were asked about any discomfort, i.e. if the panty liners were perceived as too warm or giving slight chafe or irritation. Discomfort was reported on five occasions for the conventional, non-breathable panty liner, and on two occasions each for the other liners.

DISCUSSION

It is well known that temperature plays an important role in the growth of microorganisms, a higher temperature promoting growth. In some cases the increased temperature may lead to sweating, and further favour conditions for microbial growth. The mean temperature differences between the cases found in our study are in the order of 1.5°C; the maximum absolute value was as high as 37.2°C on the vulva skin covered by the panty liner (in a case with non-breathable back sheet).

The TEWLdirectly value is the increased surface wetness due to the occlusion effect, as has been reported by others (11, 12). The finding that the panty liner with the non-breathable back sheet gave the highest difference between the direct measurement and

after 15 min, and that the TEWL value was the same at the direct measurement and after 15 min when no panty liner was used, supports this fact.

The TEWL values measured by us differ from those reported by Elsner et al. (1, 2, 3, 5), but are similar to those reported by Hanke-Baier et al. (16). The differences may be due to the fact that the investigators did not use the same sites for measurements on the *labium majus*. In our study, we placed the probe on the exterior aspect of the *labium majus* so that the site would most probably have been covered by the panty liners. Measurements with the probe placed 0.5 – 1.0 cm further outwards gave a reduction in magnitude of 20 units (g m^{-2} h^{-1}) (unpublished data).

The use of panty liners seems to influence skin surface wetness, but not 'absorbed' moisture content in the *epidermal* skin layers. The vulva skin is already quite hydrated compared to other parts of the body (5). Still, increased water content on the skin surface may be sufficient to accelerate skin flora growth. Noble (17) reports the skin as being a habitat for micro flora and that the single factor with the greatest effect on growth is undoubtedly the availability of water. Zimmerer et al. studied the skin flora dependence on patches loaded with water and found an increase of the skin flora growth with increasing water content of the patches (11). The promoting effect of skin occlusion on skin flora growth has also been shown (6, 20).

The pH at the *interlabial* fold is similar for the four cases and it is reasonable to assume that the folds are not influenced by the superficially placed products. The higher pH on the *perineum* and *labium majus* sites for the case with the non-breathable back sheet is in accordance with the finding of Aly et al. (6) that occlusion leads to a higher skin pH. Lukacs et al. (18), who reported that skin surface pH was a major factor for bacterial growth on the skin, showed that *Brevibacterium epidermidis* grew readily from pH 5.5 to 8.5, but not when pH was 5.0.

In an earlier study we showed the important role played by the pH, where experimentally induced *Candida albicans* lesions were significantly more severe at a higher skin pH than at a lower one; pH 5.7 versus 5.1 (19).

If several micro-environmental factors, i.e. temperature, humidity and pH, are lumped together, the risk of a negative influence will probably increase. Several small contributions may create enough difference to pass a threshold and change the ecological balance. What has not been studied here but deserves attention is that women with for example reduced immunological defence, damaged skin, tight crotch anatomy, poor hygiene, or who are carriers of skin diseases, could have a higher risk, even with little disturbance of the micro-environmental conditions.

Continuous use of a panty liner of the conventional type can lead to increased temperature, skin surface wetness and pH. If a panty liner has to be used, and there is a tendency for an increasing number of women to do so, it would probably be beneficial to use one with a breathable back sheet, because this influences the vulva microclimate to a lesser degree. An acidified product might further help to keep the vulva skin pH low. Further studies are needed to confirm these findings and to assess the microbiological implications of the above-mentioned differences. The finding by Schäfer et al. (9) that breathable diapers reduce the prevalence of *Candida* and diaper dermatitis supports the idea of improving skin conditions with breathable materials.

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