REVIEW ARTICLE

The pH of the vulvar region in the life cycle: scoping review

O pH da região vulvar no ciclo vital: revisão de escopo

El pH de la región vulvar en el ciclo vital: revisión del alcance

Maristela Belletti Mutt Urasaki[1]
Euzeli da Silva Brandão[2]
Rosemeire Sartori de Albuquerque[1]
Lorrany Magalhães Masson[1]
Jessica da Silva Almeida[1]

[1]Escola de Artes, Ciências e Humanidades da Universidade de São Paulo (EACH-USP), São Paulo, São Paulo, Brazil.

[2]Universidade Federal Fluminense (UFF), Niterói, Rio de Janeiro, Brazil.

Corresponding author:
Maristela Belletti Mutt Urasaki
E-mail: mari.urasaki@usp.br

How to cite this article: Urasaki MBM, Brandão ES, Albuquerque RS, Masson LM, Almeida JS. The pH of the vulvar region in the life cycle: scoping review. Rev. Eletr. Enferm. 2024;26:75717. https://doi.org/10.5216/ree.v26.75717 English, Portuguese.

Received: 28 March 2023
Accepted: 8 November 2023
Published online: 15 February 2024

ABSTRACT

Introduction: to map the studies that measured the Potential of Hydrogen (pH) of the vulvar region in women's life cycle. **Methods:** scoping review according to recommendations from the Joanna Briggs Institute (JBI) Manual for Evidence Synthesis in the SCOPUS, Web of Science, Academic Search Premier, PubMed, Bielefeld Academic Search Engine and Google Scholar databases in January 2022. Studies published in Portuguese, Spanish, French, and English, without time limit, were included. **Results:** of the 954 documents retrieved, 13 were selected. Different measurement procedures in relation to equipment, environment and preparation of participants were used in the studies. The average age of the female population ranged between 31 and 43 years. The vulvar measurement sites were the labia majora and minora, interlabial sulci and perineum. The lowest pH value measured was 4.6 and the highest was 6.3. **Conclusions:** there was a low production of studies on vulvar pH and an emphasis of studies on the population of adult women. The diversity of procedures and measurement sites found does not allow for safe statements about a range of pH values on the surface of the vulvar skin.

Descriptors: Vulva; Hydrogen-Ion Concentration; Skin; Hygiene; Weights and Measures.

RESUMO

Introdução: *mapear os estudos que mensuraram o potencial Hidrogêniônico (pH) da região vulvar no ciclo vital da mulher.* ***Métodos:*** *revisão de escopo conforme recomendações do Manual for Evidence Synthesis do Joanna Briggs Institute (JBI), nas bases SCOPUS, Web of Science, Academic Search Premier, PubMed, Bielefeld Academic Search Engine e Google Acadêmico em janeiro de 2022. Foram incluídos estudos publicados em português, espanhol, francês e inglês, sem limite temporal.* ***Resultados:*** *dos 954 documentos recuperados, 13 foram selecionados. Apurou-se que os estudos utilizaram diferentes procedimentos para as medições quanto aos equipamentos, ambiente e preparo das participantes. A média de idade apresentada pela população feminina estudada variou entre 31 e 43 anos. Os locais de medição vulvar foram os grandes e pequenos lábios, dobra interlabial e períneo. O menor valor do pH aferido foi 4,6 e o maior 6,3.* ***Conclusões:*** *constatou-se baixa produção de estudos acerca do pH vulvar e ênfase das pesquisas na população de mulheres adultas. A diversidade de procedimentos e locais de aferição encontrados não permite afirmações seguras sobre uma faixa de valor de pH da superfície da pele vulvar.*

Descritores: *Vulva; Concentração de Íons de Hidrogênio; Pele; Higiene; Pesos e Medidas.*

RESUMEN

Introducción: *mapear los estudios que midieron el Potencial de Hidrógeno (pH) de la región vulvar en el ciclo vital de las mujeres.* ***Métodos:*** *revisión del alcance según las recomendaciones del Manual for Evidence Synthesis del Joanna Briggs Institute (JBI), en las bases de datos SCOPUS, Web of Science, Academic Search Premier, PubMed, Bielefeld Academic Search Engine y Google Scholar en enero de 2022. Se incluyeron estudios publicados. en portugués, español, francés e inglés, sin límite de tiempo.* ***Resultados:*** *de los 954 documentos recuperados, se seleccionaron 13. En los estudios se utilizaron diferentes procedimientos de medición en relación con el equipo, el entorno y la preparación de los participantes. La edad media de la población femenina osciló entre 31 y 43 años. Los sitios de medición vulvar fueron los labios mayores y menores, el pliegue interlabial y el perineo. El valor de pH más bajo medido fue 4,6 y el más alto fue 6,3.* ***Conclusiones:*** *hubo una baja producción de estudios sobre pH vulvar y un énfasis de estudios en población de mujeres adultas. La diversidad de procedimientos y sitios de medición encontrados no permite realizar afirmaciones seguras sobre un rango de valores de pH en la superficie de la piel vulvar.*

Descriptores: *Vulva; Concentración de Iones de Hidrógeno; Piel; Higiene; Pesos y Medidas.*

INTRODUCTION

The vulva includes the pubis, labia majora, labia minora, clitoris, perineum, vestibular bulbs, Skene gland, urethral meatus, vestibule of the vulva, and the vaginal opening. The integument of this region has unique morphological and functional properties, which differs from other areas of the body in relation to hydration, microbial ecology, permeability and blood flow. It has a thin stratum with large hair follicles in the regions of the labia majora, and a lot of pubis and mucous membranes in the regions of the labia minora, which makes it susceptible to topical agents of various natures, such as soaps, creams, lotions, perfumes, medicines, products of hair removal and irritation[1,2]. As an aggravating factor, this region is usually exposed to various irritating substances, such as products, secretions and excretions, such as: clothing occlusion, intimate tampons, friction, sweating, menstruation, vaginal secretions and urine[3-5].

Given these characteristics, vulvar health and comfort depend on some factors, among them the potential of hydrogen[1*] (pH) of tissue.

The pH of the surface of the body skin is acidic, ranging from 4.1 to 6.0[6,7], which allows protection against pathogenic microorganisms[8]. In addition, several key enzymes are responsible for the synthesis and maintenance of skin barrier, which are widely impacted by pH[8], adding its greater importance to health.

Several factors interfere with body skin pH, such as the anatomical site, age, genetic and ethnic predisposition, sebum and sweat produced, skin hydration, use of detergents, soaps, cosmetics, occlusive dressings and use of topical antibacterial solutions[6,8-10]. In addition, it is relevant to highlight that routine hygiene practices may affect the local pH favorably or unfavorably, depending on the product used[10-12].

When it comes to the vulvar integument, note that its barrier function is more fragile in all phases of life compared to other regions of the body, and if this barrier is broken, the area exposure to numerous microorganisms, including pathogenic, increases the risk of developing vulvar infections[13,14].

In 2011, the Royal College of Obstetricians and Gynecologists published a guide on "Management of vulvar skin diseases"[15]. This important material presents several recommendations regarding skin care of this region, such as: use of specific solutions for vulvar hygiene in place of soaps, sanitizing the vulva not only with water, frequency of hygiene not exceeding twice a day, giving preference to the use of shower over a bathtub, as well as not using sponges, bath gel, scrubs, foam baths, deodorants, wet wipes and douches in the region for cleaning. However, it does not address the vulvar pH.

Given the dermatological specificities in the different areas of the vulva, that is, skin, semi-mucosa and mucosa, the Brazilian Federation of Gynecology and Obstetrics Associations (Portuguese acronym: FEBRASGO) signals that hygiene products suitable for the vulva are not necessarily suitable for the vagina or vaginal introitus[4]. Although this Federation[4] recommends the hygiene of the vulvar region up to three times a day on hot days, using products with pH between 4.2 and 5.6, this recommendation is not supported by scientific evidence and does not specify the age group to which it applies.

Maintaining the vulvar acid pH is an essential measure known to prevent irritation and disorders. The reduction of pH has been suggested as a therapeutic strategy for relieving symptoms of various vulvar dermatoses that cause significant discomfort and affect the quality of women's lives[15,16].

1 *Hydrogenionic potential or hydrogen power or hydrogen potential.

Pruritus and vulvar pain are very common complaints in women with vulvar disorders, leading them to practice self-medication, including the use of antimicrobials without prescription by a healthcare professional (physician and nurse), inducing microbial resistance, in addition to other products that alter skin pH, with consequent change in microbiota, facilitating the installation or worsening of infections in this body region[4]. To minimize this impact on women's health, the pH values of these topical products must remain within physiologically recommended values for the prevention of complications for women while treating disorders, and in the daily care of this important body region[17].

In general, scientific evidence addresses the importance of pH in maintaining body and vaginal skin health. Regarding this last region, studies that assessed the value of the vaginal pH and validated the results found, showed that the vaginal pH is 7.0 in pre-menarche, 3.8-4.4 in the reproductive age, 6.5-7.0 in menopause without hormone replacement and 4.5-5.0 with hormone replacement[10]. However, vulvar pH values are often estimated around 4.7 based on body skin pH values. There is a gap of sustained scientific evidence in primary studies with a methodological design that enables the measurement and validation of the values found.

Although the importance of identifying reference values of vulvar skin pH considering the different cycles of life (neonatal, childhood, adolescence, maturity, pregnancy, and puerperal, pre and postmenopausal period) is known, there is no systematization of scientific evidence on this theme.

A detailed knowledge of the normal representative range of the pH of the vulvar skin would allow more accurate information to support the management of the vulva by nurses and other health professionals, and ensure safe guidance on cleaning and recommendations of suitable products for women in different cycles of life.

Given the above, the objective of this study was to map the studies that measured the pH of the vulvar region in the life cycle of women in order to support clinical practice.

METHODS

This is a scoping review conducted according to the methodology of the Manual for Evidence Synthesis of the Joanna Briggs Institute (JBI)[18]. The protocol was registered with the Open Science Framework (OSF) under number https://osf.io/7J2HD/.

The Population, Concept and Context (PCC) strategy for scoping reviews was used to design the research question[18]; Participant (P) corresponds to women in their vital cycle, Concept (C) is the pH of the vulvar skin, and Context (C) the different health scenarios and their geographic locations. The process culminated in the following research question: What is the pH of the vulvar skin in the woman's life cycle in different health scenarios and their geographic locations?

The construction of the research strategy included the participation of a health science librarian, member of the JBI-Brazil main team, who helped in choosing the relevant databases to the topic investigated and in the selection of keywords for the different "strings" to be used in each database.

Initially, a preliminary search for reviews on the topic was carried out in January 2022 on the Open Science Framework (OSF), Joanna Briggs Institute (JBI) and International Prospective Register of Systematic Reviews (PROSPERO) platforms. However, registered protocols on this topic were not identified.

Next, a search was carried out on the Scopus portal (Elsevier) using the combination of the words "vulva", "pH" and "vital cycle" [title-abs-key (vulva and ph and "life cycle")] for term mining in relation to the research topic. Given the very low number of documents recovered, it was necessary to remove "life cycle". At this stage, 180 documents were retrieved and, from the reading of titles, abstracts and keywords, new search words to be tested were identified. The following remained in the group for the definitive strategy: vulva, vulvar vestibule, skin, pH, acid mantle, hydrogen ion concentration, evaluation and measurement.

The definitive search strategies were established in the following databases: *Scopus* (*Elsevier*) search 1: *title*-abs *key (ph and vulva) and (exclude (subjarea, "vete") or exclude (subjarea, "agri"))*, search 2: *(title-abs-key ((ph or {hydrogen ions concentration} or {acidmantle})) and title-abs-key (vulva or {vulvar vestibule}))*, search 3: *(title-abs ("ph measurement" and skin)) and (human); Web of Science Core Collection (Clarivate Analytics): (ph or "acid mantle" or "hydrogen ions concentration") and (vulva or "vulvar vestibule"); Academic Search Premier (Ebsco): (ph or "acid mantle" or "hydrogen ions concentration") and (vulva or "vulvar vestibule"); PubMed ((LM/NCBI): ("pH measurement" [all fields] and ("skin"[mesh terms] or "skin"[all fields])) and (humans[filter]); Bielefeld Academic Search Engine - BASE (Bielefel University): (ph or "acid mantle" or "hydrogen ions concentration") and (vulva or "vulvar vestibule") in subject and Google scholar (*Google*)* search 1: *ph or "acid mantle" or "hydrogen ions concentration" and vulva or "vulvar vestibule"*, search 2: *(ph or "hydrogen ions concentration" or "acid mantle") and skin* and search 3: *(ph or "hydrogen ions concentration" or "acid mantle") and skin and assessment.*

A search was also carried out in the Catalog of Theses and Dissertations of the Coordination for the Improvement of Higher Education Personnel (Portuguese Acronym: Capes), Cybertesis Repositorio de Teses Digitalis, Digital Library of Theses and Dissertations/University of São Paulo, The DART-Europe E-theses, Scientific Open Access Repositories of Portugal (RCAAP) and Google Scholar.

All primary studies that measured the pH of the vulvar skin were considered as sources of evidence, namely: experimental, quasi-experimental, randomized, non-randomized, before and after studies, clinical trials and case reports, published in Portuguese, Spanish, French and English and without time limit.

The following were excluded: opinion articles, comments, book chapters and books, experimental research on animals, studies that only presented vaginal pH values (as it is part of the internal genitalia) and not the vulvar pH, studies measuring the pH of products for vulvar use, pH assessment under conditions of vulvar disease and research into theoretical bases and pH measurement methods.

All documents found were exported to the bibliographic reference management software EndNote Basic (Online version, 2019, Clarivate Analytics®, United States of America) to exclude duplicate documents.

The titles and abstracts of the selected articles were independently evaluated by two researchers. Disagreements were resolved based on pre-defined criteria: description of the equipment used to measure pH and details of the procedures.

The articles that met the inclusion criteria were read in full, including the analysis of references in search of potentially unrecovered documents and expansion of the results. For this phase, the researchers formed pairs, who analyzed the texts independently. There was no disagreement between them during the selection. The remaining studies were imported into Excel® software (version 2016, Microsoft Office, United States of America) by the reviewers independently.

For the final analysis of the articles, an instrument adapted from the JBI[18] aligned with the objective of this investigation was used. It was previously tested and included the following variables: characterization of the publication (authorship, title, year, journal and country of origin), objective of the study, type of study, population and sample size, place of origin of the population and measurement of the pH of the skin surface specifying the period of the life cycle investigated, measurement method and the control of intervening factors.

The main focuses were analyzed and the results are presented in a descriptive way, summarized in tables and narrated verbatim.

RESULTS

Initially, 954 articles, dissertations and theses were recovered. After analysis following the previously established steps, 13 articles remained (Figure 1), in which recurrence of authors and replication of studies were found (same authors - articles H, I and J; half of the authors of articles H, I and J are authors of article G; articles K, L and M have the same authors; and part of the authors of articles K, L and M are also authors of articles D, E and F).

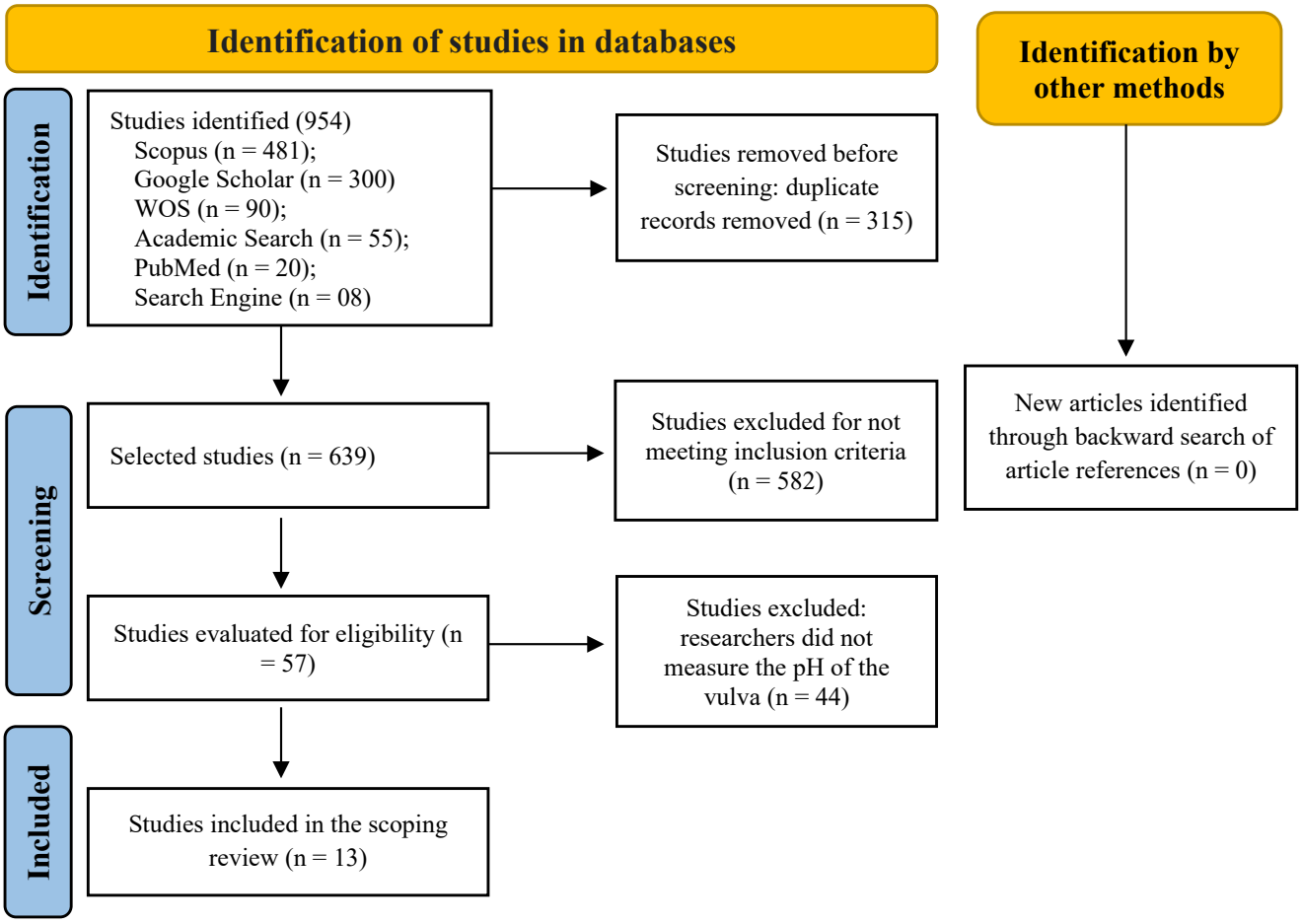
The period covered by the publications was from 1990 to 2020, all published in English. The most frequent country of origin was the United States of America (USA) (Table 1)[19-31]. Two articles (B and C) were published in journals in the field of Biology and the others in the field of Dermatology. Among these experimental studies, six (A, B, F, K, L and M) were clinical trials.

All articles (Table 1) included pH as an evaluation parameter considering their different objects of investigation: the effect of the use of cleaning solutions on the pH of the vulvar skin (A and B), evaluation of the physiology of the vulvar skin (D and E), the relationship between the type of panties and the vulvar microenvironment (H and I), the impact of the use of intimate pads on the vulvar microclimate (F and J), the effect of physical trauma on the vulvar skin and forearm (K), the irritability of the vulvar skin and forearm after exposure to abrasive substances (L), the effect of prolonged drying of the vulvar skin (M), the effect of different physiological factors of the vulvar skin on the recurrence of herpes simplex virus type 2 (G), the impact of increasing the pH of the vulvar skin on the microbial ecology of this region (I), the association between obesity and changes in the biophysical properties and microbiome of the vulvar and abdominal skin (C).

The study population ranged from nine (L) to 102 (I), totaling 499 participants, all over 18 years old, a maximum age of 87 years. Approximately half of the studies excluded pregnant women and nursing mothers (A, B, C, D, E and F); others included only women with regular menstruation (F, H, I and J), one included only postmenopausal women (M) and another included women of fertile age and postmenopausal women (E).

In the studies analyzed, the different procedures used for the control of factors involved in pH measurements were grouped into three major themes: Measures to control equipment and measurement techniques; Environmental control measures; and Measures (Criteria) for inclusion of participants in studies (Table 2).

Figure 1 - Flow diagram of search and selection of studies according to the PRISMA model, 2022



The location and time of measuring vulvar pH varied across studies (Table 3). In most studies (A, D, E, G, H, I and J), measurement was performed in two or more locations in the vulva. In two, the measurement was carried out consecutively, more than once in the same location (C and F). In intervention studies, pH was measured before and after interventions (A, B, F, K, L and M).

One study stipulated the measurement period between the 14th and 21st day of the menstrual cycle (C), while others established the premenstrual days and immediately after the end of each menstrual cycle as desirable (F), or between the 16th and 22nd day of the menstrual cycle (G, H, I and J).

The measurement was carried out using different models/brands of measuring equipment (Table 3). The detailed description of the equipment was mentioned in only one study (A) and another (G) only mentioned the type of electrode used. No study presented values measured individually for each participant, including those with small samples. Only the mean and standard deviation were presented, except for four studies that presented the mean but did not report the standard deviation. The findings of pH values from studies with interventions presented in Table 3 correspond to the measurements before interventions.

In order to summarize the results, Figure 2 presents the range of pH values found in the different vulvar regions, considering the respective standard deviations.

DISCUSSION

By presenting the mapping of the production of knowledge on measurements of the pH of the surface of the vulva, this study reveals the scarcity of research on the subject. It is important to highlight the recurrence of authors in more than one journal and replication of studies. The researchers of articles H, I and J are the same and half of them are authors of article G. The authors of articles K, L and M are the same, and in articles D, E and F, some of the researchers are also the same.

Scientific production on measuring the pH of the surface of the vulvar skin is scarce, concentrated in a few countries and authors, which weakens the generalization

Table 1 - Records included by the scoping review, according to title, objectives and country of origin, 2022

Cod.	Study design	Year/ country*	Title	Objectives
A	Controlled clinical trial	2020 Italy	*Characterization of female intimate hygiene practices and vulvar health: a randomized double-blind controlled trial*[19]	To evaluate the effects of daily use of intimate cleansers on vulvar skin by comparing two specific intimate care products; one based on a natural extract (*Saugella Hydraserum Saugella* – SIS) and the other based on lactic acid (*Lactacyd Feminine Hygiene* – LTC).
B	Uncontrolled clinical trial	2020 United Kingdom	*A 28-day clinical assessment of a lactic acid containing antimicrobial intimate gel wash formulation on skin tolerance and impact on the vulvar microbiome*[20]	To evaluate the subjective tolerance of the gel, when used in the external genital area at least once a day; evaluate the tolerance to hydration and the pH of the vulva.
C	Observational, analytical study	2019 United States of America	*Comparative study of vulva and abdominal skin microbiota of healthy females with high and average BMI*[21]	To determine if obesity is associated with changes in the biophysical properties and microbiome of the vulva and abdominal skin.
D	Observational, descriptive study	2013 Japan	*Study of the vulvar skin in healthy Japanese women: components of the stratum corneum and microbes*[22]	To investigate the physiology of vulvar skin in Japanese women, focusing on inflammatory cytokines and microorganisms.
E	Observational, descriptive study	2013 Thailand	*Characterization of vulvar skin of healthy Thai women: influence of sites, age and menopause*[23]	To investigate the properties of the vulvar skin of Thai women, focusing on the functional properties of the stratum corneum.
F	Clinical trial	2011 United States of America	*An investigator blinded cross-over study to characterize the cutaneous effects and suitability of modern sanitary pads for menstrual protection for women residing in the USA*[24]	To examine the cutaneous effects and suitability for practical use of two types of commercially available disposable sanitary pads.
G	Observational, analytical study	2006 Sweden	*The microenvironment of vulvar skin in women with symptomatic and asymptomatic herpes simplex virus type 2 (HSV-2) infection*[25]	To study the interference of local factors in recurrence or silent infection in individuals infected with Herpes Simplex Virus Type 2 (HSV-2)
H	Experimental study	2005 Sweden	*The vulvar skin microenvironment: impact of tight-fitting underwear on microclimate, pH and microflora*[26]	To investigate if the design of panties (thong and regular panties) affects the vulvar skin microenvironment differently
I	Experimental study	2004 Sweden	*The vulvar skin microenvironment: influence of different panty on temperature, pH and microflora*[27]	To evaluate if vapor-impermeable panty liners harm the microclimate of the vulvar skin; evaluate the impact on microflora, describe microflora under different conditions and evaluate if the increase in temperature, humidity and pH is sufficient to influence microbial ecology.
J	Experimental study	2003 Sweden	*The vulva skin microclimate: influence of panty liners on temperature, humidity and pH*[28]	To investigate how panty liners influence the climate of the vulva skin (temperature, surface humidity and pH).
K	Clinical trial	1991 United States of America	*Standardized trauma (tape stripping) in human vulvar and forearm skin: effects on transepidermal water loss, capacitance and pH*[29]	To evaluate the effect of standardized physical trauma on vulvar skin and compare responses with the reaction of forearm skin in the same person.
L	Clinical trial	1990 United States of America	*Multiple parameter assessment of vulvar irritant contact dermatites*[30]	To evaluate the irritant response of vulvar and forearm skin induced by 3% sodium lauryl sulfate in healthy premenopausal women.
M	Clinical trial	1990 United States of America	The effect of prolonged drying on transepidermal water loss, capacitance and pH of human vulvar and forearm skin[31]	To evaluate the effect of prolonged drying on transepidermal water loss, capacitance and pH of vulvar and forearm skin.

Note: *Country of data collection; Cod: article code; pH: potential of Hydrogen; BMI: Body Mass Index.

Table 2 - Procedures adopted to control factors involved in measuring the pH of the vulvar region, 2022

Measures to control equipment and measurement techniques
• Compliance with standardized measurement conditions (without details of actions) (A and G);
• Daily instrument calibration with pH buffers 4 and 7 (C, H, I, J and M);
• Probe recalibration when pH calibration is outside the range of ± 0.1 (C);
• Cleaning the probe with deionized water before each measurement and with the last drops kept on the electrode to provide a moist state on the skin during the measurement (H, I and J);
• Immersion of the probe in a 10% bleach solution for at least ten minutes between each subject, rinsing thoroughly with deionized water and storing in deionized water when not in use (C);
• Application of 0.2 ml of distilled water (pH 7.0) at the measurement site, contact of the electrode in the fluid, pressure on the skin and removal of excess water (M);
• Application of 0.01 ml of saline solution to the surface of the skin before checking with a pH strip (D);
• Brief contact of the probe with the skin (about three seconds for each reading) (C);
• Waiting approximately 30 seconds to record the reading (H, I and J);
• Measurement carried out after stabilization of the pH reading (M);
• Cleaning the electrode with alcohol for each participant (F, H, I and J).
Environmental control measures
• Room temperature and humidity control (22 ± 2°C and 45 ± 5% relative humidity) (A);
• Temperature 22–25°C and 50–70% relative humidity monitored by a simple thermo-hygrometer (E);
• Room temperature of 20°C and relative humidity of 50-60% (K);
• Air conditioning the room for 15 minutes (C).
Measures (Criteria) for inclusion of participants in studies
• Absence of active vulvovaginal infection or vulvar dermatosis (A, B, C, D, E, F, G, H and I); STI (E);
• Absence of piercing and/or tattoo in the vulvar region (C);
• No use of antibiotics or vaginal medication four weeks before measurement (G, H and I), in last three months (B), in last two weeks (D);
• Not having changed contraceptives or hormones in the last three months (B);
• No history of allergy to intimate pads or their substances (E and F);
• No use of any systemic medications to treat yeast, any topical products, antipruritic or antifungal medications for the genital area and oral antibiotics within two weeks (F), six weeks (C), known allergy to fragrances, positive cultures (F);
• Regular menstrual cycle for at least one year (D and E), last three months (C); regular menstrual cycle (H and I), absence of menstruation on the day of measurement (D);
• Absence of body hygiene on the morning of pH measurement and in the external genital area for at least 8 hours and no more than 16 hours before evaluation (B), absence of body hygiene, exercise or swimming in the last 4 hours (C);
• No application of any products to the external genital area or change of brand of usual products during the study (B) in the last 24 hours (C);
• Maintaining the morning schedule for body hygiene (E);
• Cleaning the genitalia with only water the night before the measurement (G, H, I and J);
• No use of antibacterial soap when cleaning (G, H, I and J);
• Avoiding sexual activity for at least 24 hours before the measurement (E), the night before the exam (G, H, I and J), in the last 48 hours (C);
• Not shaving the genital area in the previous three days (C, G, H, I and J);
• No use of cigarettes or any substance containing caffeine in the last two hours of measurement (C);
• Participants remain in the room for fifteen minutes before taking the measurement (C, D, E, G, H, I, J, K, L and M).

Note: pH: potential of hydrogen.

of results, as the pH can vary depending on the climate, social, cultural and religious factors, in addition to the cleaning practice adopted in the vulvar region[10,32].

These variations were found in studies that evaluated the pH of body skin in different situations, such as pH values and epidermal barrier function in different ethnicities[33], changes in skin pH in occupational environments[9] and according to practices of body hygiene in certain social groups[14].

A small number of articles was found, the participants of studies were women between 18 and 87 years of age, partially covering the life cycle (fertile age, pre-menopause, menopause and post-menopause), not making it possible to know the pH of the vulvar region in childhood and the first years of fertile age. Therefore, there is a need to develop studies evaluating vulvar pH in the different cycles of women's lives, as evidence indicates a change in body pH according to

Table 3 - Description of the pH measurement region of the vulva, the values found and the equipment used for measurement, 2022

Cod*	Life cycle	Measurement region	Average pH values	Equipment brand
A	Fertile age (18 years until before menopause)	Middle third of the labia majora and middle third of the labia minora	5.60 – 5.20*	*Skin-pH-Meter®* pH 905
B	Fertile age (18 to 55 years and less than 2-3 menopause symptoms)	Middle part of the labia majora	5.88*	*Multi Probe Adaptor System skin-pH meter®* pH 905.
C	Fertile age (18 to 35 years old)	Labia majora	Average BMI = 5.92 ± 0.64† High BMI = 6.36 ± 0.58†	*Courage and Khazaka pH meter® Cologne, Germany.*
D	Fertile age (22 to 39 years old)	Lower part of the labia majora, pubis and inner thigh	6.00 ± 0.3†,‡	pH test strip paper, pH 4.0 – 9.0; *AS ONE Corp.*, Osaka, Japan).
E	Fertile age (20-69 years old, including post-menopause)	Labia majora and labia minora	6.60 6.30	*Skin pH-Meter® pH 905, Courage and Khazaka.*
F	Fertile age (18 to 50 years old and regular menstrual cycle)	Upper part of the labia majora	4.62 ± 0.42*,†,	No specification
G	Fertile age (25 to 44 years old)	Labia majora and perineum	5.30 ± 0.14† 5.40 ± 0.13†	Mettler-Toledo electrode
H	Fertile age (23 to 45 years old and regular menstrual cycle)	Inner part of the labia majora and perineum	A - panties with normal lining labia majora = 5.40 ± 0.12† perineum 5.60 ± 0.17† B - thong panties labia majora = 5.60 ± 0.15† perineum = 5.50 ± 0.14†	pH 900 *Courage and Khazaka®, - Cologne, Germany* with Mettler-Toledo 304 flat electrode
I	Fertile age (20 to 45 years old and regular menstrual cycle)	Upper part of the labia majora and perineum	A - unlined panties labia majora = 5.20 perineum = 5.60 B – panties with non-breathable lining labia majora = 6.00 perineum = 6.00 C – panties with acidic and breathable lining labia majora = 5.30 perineum = 5.50.	pH 900 *Courage and Khazaka®, Cologne, Germany* with Mettler-Toledo 304 flat electrode
J	Fertile age (32 to 45 years old)	Labia majora, interlabial sulci and perineum	A – unlined panties labia majora = 5.20 ± 0.1† interlabial sulci = 5.50 ± 0.1† perineum = 5.60 ± 0.1† B – panties with non-breathable lining labia majora = 5.80 ± 0. 1† interlabial sulci = 5.60 ± 0. 1† perineum = 6.10 ± 0.1† C – panties with breathable lining labia majora = 5.30 ± 0.1† interlabial sulci = 5.50 ± 0.1† perineum = 5.90 ± 0.1† D – panties with acidified and non-breathable lining labia majora = 5.40 ± 0.1† interlabial sulci = 5.60 ± 0.1† perineum = 5.60 ± 0.2†	pH 900 *Courage and Khazaka®, Cologne, Germany* – with Mettler-Toledo 304 flat electrode

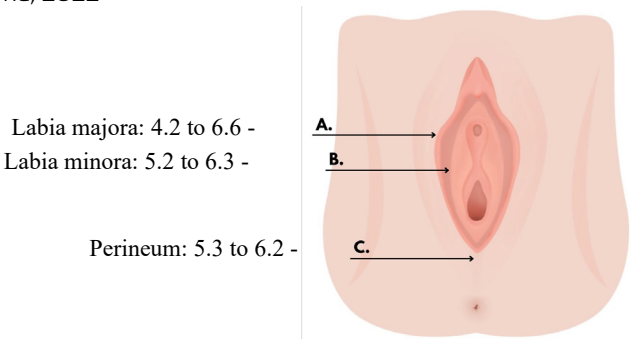
Continue...

Table 3 - Continuation

Cod*	Life cycle	Measurement region	Average pH values	Equipment brand
K	Fertile age (28 to 45 years old)	Middle third of the labia majora	5.50 ± 0.5*,†	pH 900 *Courage and Khazaka®, Cologne, Germany* - with Mettler-Toledo 304 flat electrode
L	Fertile age (22 to 35 years old)	Middle third of the labia majora	5.60 ± 0.1*,†	pH-meter PC. *Courage and Khazaka®, Cologne, Germany*
M	Post-menopause (50 to 87 years old)	Middle third of the labia majora	6.05 ± 0.1*,†	pH 125. *Corning, Medfield, Mass®* Orion flat surface pH electrode, Boston. Mass

Note: *Day zero; †Standard deviation; ‡Although differences between the three locations were found, they were not presented in the article; Cod: Article code; BMI: body mass index.

Figure 2 - Identification of the regions of the vulva and the respective range (standard deviation) of pH values found, 2022



the age group[8]. For example, the vaginal pH in childhood is alkaline, during puberty it is more acidic, in the premenstrual phase it varies from 3.8 to 4.2, at the beginning of the menstrual phase it increases to 6.0 to 7.2 and decreases again to 4.0 to 5.0 during the rest of the cycle[1,4], and at menopause it reaches pH values of 6.0 or 7.0 (neutral)[34].

In this review, the vulvar pH measured in the labia majora of postmenopausal older women (study M, pH = 6.05 ± 0.1) was close to values found in the same site for women of fertile age in other studies (C = 5.92 ± 0.64; D = 6.00 ± 0.3; I = 6.00) and in the group of panties with non-breathable lining (study J, pH = 5.80 ± 0.1). The authors of study E considered women of fertile age and postmenopausal women as the population, those of study B included women of fertile age with up to two and three symptoms of menopause, and women of study A even before menopause. However, the researchers did not present pH values distinctly obtained in the respective periods of life, limiting the comparison between them.

Another gap identified in this review was the lack of information about pH in the population of pregnant women and nursing mothers, since ten of the studies considered this population as exclusion criteria. The lack of information about the pH of the vulvar skin of this population has a direct impact on self-care for this part of the body, as guidance on vulva care, both for pregnant women with intact skin and for postpartum women with perineal trauma, must be evidence based and not just based on the clinical practice of the health professional[35].

Although the practice of intimate hygiene is a routine activity among women in different cultures, inappropriate practices that negatively impact women's health are still observed. Education with safe guidelines is essential to promote vulvar health[36].

Measuring the pH of the vulvar skin is not a simple action, as endogenous (physiological), exogenous, environmental and instrumentation factors affect the result. Therefore, it is necessary to adopt environmental control measures, equipment and precise guidelines regarding vulvar skin care and other important aspects that may interfere with the measurement. These can minimize the impact of such factors on the results and are well established through protocols and guidelines available in the scientific literature[7].

However, in the studies analyzed, in general, little or almost no environmental control measures or measurement equipment were adopted by the researchers, especially in two studies (K and L) that mention only two measures, weakening the results found. In turn, the guidelines regarding the care to be adopted by participants were more addressed. Most studies made restrictions for evaluating vulvar skin conditions, with emphasis on local hygiene recommendations. The researchers sought to meet some of the specifications of the measurement protocols, even though extra and peculiar conditions were established in a study, such as the recommendation not to smoke or ingest caffeine in the previous two hours before the measurement (C).

It is essential to inform participants in pH measurement research about skin hygiene, the type of soap to be adopted, as well as the indication of using or abstaining from topical products, such as cosmetics and lotions. Furthermore, it is recommended to clean the vulvar skin with water two to three hours before the measurement, up to ten hours when using alkaline soaps and twelve hours after using ointments, body lotions and other topical products in the measurement area[7,37].

The most used equipment by researchers to measure vulvar pH was pH 900 (Courage and Khazaka®, Cologne, Germany) with a Mettler-Toledo 304 flat electrode. The flat electrode, also known as a single glass rod electrode, is currently the universally used and most accepted method for measuring the pH of the surface of healthy and diseased skin[7]. This reinforces the importance of using quality equipment in order to obtain more reliable results.

Regarding the place to measure the pH of the surface of the vulvar region, to date, no standardized location has been defined for the measurements. This fact is observed in the studies analyzed, since pH measurement was carried out in different areas of the vulva (labia majora and minora, perineum, interlabial sulci, pubis, inner thigh). According to the European Group on Efficacy Measurement of Cosmetics and Other Topical Products (EEMCO), comparing skin pH results from different anatomical sites may be inappropriate, as the composition of the skin surface is not necessarily uniform[38]. Although this observation refers to the organism as a whole, this information is very important considering that the vulvar skin is a special segment, transitional in nature, that is, it is a transition zone from keratinized skin to a non-keratinized mucosal epithelium[1].

When it comes to mucous membranes, unlike the skin, the situation is more diverse, as it is a humid environment with its surface pH changing depending on local secretions. The nasal mucosa, for example, is covered by a mucoid secretion with a pH of around 5.5, as well as the ocular mucous membranes, which, as they are in contact with the tear secretion, have a neutral pH (7.0). The pH of the vaginal mucosa is more acidic (3.8 to 4.2), changing according to variations in the conversion of lactate into lactic acid and other influencing processes[38,39]. A slightly wider vaginal pH range (3.8 to 4.4) is also accepted by some authors[10].

Varying pH values of the vulvar integument were found in the studies analyzed. These results should be interpreted with caution by taking into account the use of different methods, control of intervening factors and areas of evaluation on the vulvar skin. It does not seem safe to establish an average pH or a pH value range as there were significant difference in results that made up the review. Furthermore, based on the results, it does not seem prudent to use the term vulvovaginal when dealing with pH, as it has been done in other situations[40]. The pH values of the vulvar region found in this review are higher than the vaginal pH values described in the literature by scholars who carried out this measurement[41-43]. The vulvar pH should be mentioned separately from the vaginal pH.

One should not ignore the fact that small differences in pH value can reflect significant changes at the molecular level[44]. Scholars declare that a change in pH of + 0.5 units already results in functional abnormalities of the stratum corneum, decreased function of the epidermal barrier and production of negative effects on the local microbiota, such as reduced growth of the resident microbiota, increased colonization by pathogenic agents, loss of adhesion of bacteria to the skin surface and impact on antimicrobial defense mechanisms. Therefore, changes in physiological pH completely unbalance the local microenvironment[45].

The increase in vaginal pH after menopause is associated with the loss of the skin's natural defenses and increased rate of colonization with microbial pathogens in the vagina and urinary tract, which results in defective enzymatic function of the vulvar skin and intraepithelial ceramide deficiency, thereby leading to greater vulvar susceptibility to contact dermatitis[16,39].

It is well established that a high pH promotes a different microbiome that is more prone to changes[6]. The acidic pH in the vulva vestibule area is essential to maintain a normal vulvar and vaginal microbiota necessary for protection against infection[32]. Hygiene products with a high pH disturb the local balance and depending on the product, can increase the pH of the skin's surface by up to + 3.0 units[45]. Researchers maintain that the pH of the skin's surface increases even after a single cleaning procedure or after rinsing the skin with just water (pH 7.0), requiring around six hours for recovery of the pH to a physiological level. This effect is even more pronounced when alkaline soap is used[45,46].

Many intimate hygiene products are offered for cleaning and/or odor control in liquids, bars, sprays, foams, wipes and creams, which attracts the female public to purchase them[10,35]. However, publications on external topical hygiene and the role played by intimate hygiene in controlling unpleasant symptoms and supporting genital health are scarce[10].

These concepts are fundamental to guide health professionals in their conduct regarding intimate hygiene and maintenance of the natural homeostasis of the vulvar skin[36].

The challenge for future studies on pH measurement is to develop more consistent protocols in order to add greater reliability to the results.

CONCLUSION

Based on the mapping carried out, we have a better understanding of the pH values of the vulvar integument in healthy women, providing a reference for future studies. The diversity of measurement methods and locations still does not allow for safe statements about the average pH or range of pH values of the vulvar surface. The researchers focused on adult women, and a gap in knowledge on this topic at different stages of the life cycle remained.

FUNDING

This study did not receive financial support.

CONFLICT OF INTEREST

None.

ACKNOWLEDGEMENTS

The authors thank the contribution of Juliana Akie Takahashi, librarian member of JBI Brasil, for her support in developing the document search strategy.

AUTHORS' CONTRIBUTIONS - CRediT

MBMU: conceptualization; data curation; formal analysis; investigation; methodology; project administration; resources; supervision; visualization; writing – original draft; writing – review and editing.

ESB: conceptualization; data curation; formal analysis; investigation; methodology; visualization; writing – original draft; writing – review and editing.

RSA: conceptualization; data curation; formal analysis; investigation; methodology; visualization; writing – original draft; writing – review and editing.

LMM: conceptualization; data curation; formal analysis; investigation; visualization; writing – original draft; writing – review and editing.

JSA: conceptualization; data curation; formal analysis; investigation; visualization; writing – original draft; writing – review and editing.

REFERENCES

1. Farage MA, Maibach HI. Tissue structure and physiology of the vulva. In: Farage MA, Maibach HI, editors. The vulva: physiology and clinical management. Boca Raton: CRC Press; 2017. p. 6-13. https://doi.org/10.1201/9781315113739

2. Farage MA, Lennon L, Ajayi F. Products used on female genital mucosa. Curr Probl Dermatol. 2011;40:90-100. https://doi.org/10.1159/000321058

3. Al-Niaimi F, Felton S, Williams J. Patch testing for vulval symptoms: our experience with 282 patients. Clin Exp Dermatol. 2014 June;39(4):439-42. https://doi.org/10.1111/ced.12330

4. Federação Brasileira das Associações de Ginecologia e Obstetrícia (FEBRASGO). Guia prático de condutas. Higiene genital feminina [Internet]. 2009 [cited 2022 Sep 15]. Available from: https://missali.site.med.br/fmfiles/index.asp/::XPR3638::/Guia_de_Higiene_Feminina.pdf

5. Earage MA. Vulvar susceptibility to contact irritants and allergens: a review. Arch Gynecol Obstet. 2005;272(2):167-72. https://doi.org/10.1007/s00404-005-0732-4

6. Proksch E. pH in nature, humans and skin. J Dermatol. 2018 Sep;45(9):1044-52. https://doi.org/10.1111/1346-8138.14489

7. du Plessis JL, Stefaniak AB, Wilhelm KP. Measurement of skin surface pH. Curr Probl Dermatol. 2018;54:19-25. https://doi.org/10.1159/000489514

8. Ali SM, Yosipovitch G. Skin pH: from basic science to basic skin care. Acta Derm Venereol. 2013 May;93(3):261-7. https://doi.org/10.2340/00015555-1531

9. van Rensburg SJ, Franken A, Du Plessis JL. Measurement of transepidermal water loss, stratum corneum hydration and skin surface pH in occupational settings: a review. Skin Res Technol. 2019 Sep;25(5):595-605. https://doi.org/10.1111/srt.12711

10. Chen Y, Bruning E, Rubino J, Eder SE. Role of female intimate hygiene in vulvovaginal health: global hygiene practices and product usage. Womens Health (Lond). 2017 Dec;13(3):58-67. https://doi.org/10.1177/1745505717731011

11. Umami A, Paulik E, Molnár R, Murti B. The relationship between genital hygiene behaviors and genital infections among women: a systematic review. Journal Ners. 2022;17(1):89-101. https://doi.org/10.20473/jn.v17i1.34402

12. Felix TC, Araújo LB, Röder DVDB, Pedroso RS. Evaluation of vulvovaginitis and hygiene habits of women attended in primary health care units of the family. Int J Womens Health. 2020 Jan;12:49-57. https://doi.org/10.2147/IJWH.S229366

13. Summers PR, Hunn J. Unique dermatologic aspects of the postmenopausal vulva. Clin Obstet Gynecol. 2007 Sep;50(3):745-51. https://doi.org/10.1097/GRF.0b013e3180db96ae

14. van der Meijden WI, Boffa MJ, Ter Harmsel B, Kirtschig G, Lewis F, Moyal-Barraco M, et al. 2021 European guideline for the management of vulval conditions. J Eur Acad Dermatol Venereol. 2022;36(6):952-72. https://doi.org/10.1111/jdv.18102

15. Royal College of Obstetricians & Gynaecologists. The management of vulval skin disorders [Internet]. RCOG; 2011 [cited 2022 Dez 13] Available from: https://bssvd.org/wp-content/uploads/2018/06/RCOG-Vulval-Guidelines-1.pdf

16. Kaur J, Kalsy J. Study of pruritus vulvae in geriatric age group in tertiary hospital. Indian J Sex Transm Dis AIDS. 2017 Jan-Jun;38(1):15-21. https://doi.org/10.4103/0253-7184.192632

17. Edwards D, Panay N. Treating vulvovaginal atrophy/genitourinary syndrome of menopause: how important is vaginal lubricant and moisturizer composition? Climacteric. 2015 Apr;19(2):151-61. https://doi.org/10.3109/13697137.2015.1124259

18. Peters MDJ, Godfrey C, McInerney P, Munn Z, Tricco AC, Khalil H. Chapter 11: Scoping Reviews (2020 version) [Internet]. In: Aromataris E, Munn Z, editors. JBI Manual for Evidence Synthesis. JBI; 2020 [cited 2022 Dec 13]. Available from: https://synthesismanual.jbi.global/

19. Murina F, Caimi C, Felice R, Di Francesco S, Cetin I. Characterization of female intimate hygiene practices and vulvar health: a randomized double-blind controlled trial. J Cosmet Dermatol. 2020 Oct;19(10):2721-6. https://doi.org/10.1111/jocd.13402

20. Bruning E, Chen Y, McCue KA, Rubino JR, Wilkinson JE, Brown ADG. A 28 day clinical assessment of a lactic acid-containing antimicrobial intimate gel wash formulation on skin tolerance and impact on the vulvar microbiome. Antibiotics (Basel). 2020 Feb;9(2):55. https://doi.org/10.3390/antibiotics9020055

21. Vongsa R, Hoffman D, Shepard K, Koenig D. Comparative study of vulva and abdominal skin microbiota of healthy females with high and average BMI. BMC Microbiol. 2019 Jan;19(1):16. https://doi.org/10.1186/s12866-019-1391-0

22. Miyamoto T, Akiba S, Sato N, Fujimura T, Takagi Y, Kitahara T, et al. Study of the vulvar skin in healthy Japanese women: components of the stratum corneum and microbes. Int J Dermatol. 2012 Dec;52(12):1500-5. https://doi.org/10.1111/j.1365-4632.2012.05582.x

23. Fujimura T, Sato N, Ophaswongse S, Takagi Y, Hotta M, Kitahara T, et al. Characterization of vulvar skin of healthy Thai women: influence of sites, age and menopause. Acta Derm Venereol. 2013 Mar;93(2):242-5. https://doi.org/10.2340/00015555-1534

24. Fujimura T, Sato N, Takagi Y, Ohuchi A, Kawasaki H, Kitahara T, et al. An investigator blinded cross-over study to characterize the cutaneous effects and suitability of modern sanitary pads for menstrual protection for women residing in the USA. Cutan Ocul Toxicol. 2011 Sep;30(3):205-11. https://doi.org/10.3109/15569527.2011.554936

25. Löwhagen GB, Bonde E, Forsgren-Brusk U, Runeman B, Tunbäck P. The microenvironment of vulvar skin in women with symptomatic and asymptomatic herpes simplex virus type 2 (HSV-2) infection. J Eur Acad Dermatol Venereol. 2006 Oct;20(9):1086-9. https://doi.org/10.1111/j.1468-3083.2006.01729.x

26. Runeman B, Rybo G, Forsgren-Brusk U, Larkö O, Larsson P, Faergemann J. The vulvar skin microenvironment: impact of tight-fitting underwear on microclimate, pH and microflora. Acta Derm Venereol. 2005;85(2):118-22. https://doi.org/10.1080/00015550410024562

27. Runeman B, Rybo G, Forsgren-Brusk U, Larkö O, Larsson P, Faergemann J. The vulvar skin microenvironment: influence of different panty liners on temperature, pH and microflora. Acta Derm Venereol. 2004;84(4):277-84. https://doi.org/10.1080/200484277284

28. Runeman B, Rybo G, Larkö O, Faergemann J. The vulva skin microclimate: influence of panty liners on temperature, humidity and pH. Acta Derm Venereol. 2003;83(2):88-92. https://doi.org/10.1080/00015550310007409

29. Wilhelm D, Elsner P, Maibach HI. Standardized trauma (tape stripping) in human vulvar and forearm skin. Effects on transepidermal water loss, capacitance and pH. Acta Derm Venereol. 1991;71:123-6. PMID: 1675519.

30. Elsner P, Wilhelm D, Maibach HI. Multiple parameter assessment of vulvar irritant contact dermatitis. Contact Dermatitis. 1990 July;23(1):20-6. https://doi.org/10.1111/j.1600-0536.1990.tb00078.x

31. Elsner P, Maibach HI. The effect of prolonged drying on transepidermal water loss, capacitance and pH of human vulvar and forearm skin. Acta Derm Venereol. 1990;70(2):105-9. PMID: 1969192.

32. Kaur P, Patil RK, Bansal R, Patil HC. A review of practices related to genital hygiene and its awareness in women. Panacea Journal of Medical Sciences. 2021;11(3):366-9. https://doi.org/10.18231/j.pjms.2021.074

33. Voegeli R, Gierschendorf J, Summers B, Rawlings AV. Facial skin mapping: from single point bio-instrumental evaluation to continuous visualization of skin hydration, barrier function, skin surface pH, and sebum in different ethnic skin types. Int J Cosmet Sci. 2019 Oct;41(5):411-24. https://doi.org/10.1111/ics.12562

34. Monti M. Chamomile extract in a cleansing wash (Saugella Poligyn) in menopause hygiene. Global Science Research Journals [Internet]. 2016;4(1):162-6.

35. Banga L. The microbiota of the vulva and vagina: ways of washing to optimise the protective function of the vulvo-vaginal microbiota during pregnancy. New Zealand College of Midwives Journal. 2021;57:34-40. https://doi.org/10.12784/nzcomjnl57.2021.5.34-40

36. Attieh E, Maalouf S, Roumieh D, Abdayem P, Abitayeh G, Kesrouani A. Feminine hygiene practices among female patients and nurses in Lebanon. Reprod Health. 2016 May;13(1):59. https://doi.org/10.1186/s12978-016-0182-4

37. Stefaniak AB, du Plessis J, John SM, Eloff F, Agner T, Chou TC, et al. International guidelines for the in vivo assessment of skin properties in non-clinical settings: part 1. pH. Skin Res Technol. 2012 Dec 26;19(2):59-68. https://doi.org/10.1111/srt.12016

38. Parra JL, Paye M; EEMCO Group. EEMCO guidance for the in vivo assessment of skin surface pH. Skin Pharmacol Appl Skin Physiol. 2003 May-Jun;16(3):188-202. https://doi.org/10.1159/000069756

39. Linhares IM, Summers PR, Larsen B, Giraldo PC, Witkin SS. Contemporary perspectives on vaginal pH and lactobacilli. Am J Obstet Gynecol. 2011 Feb;204(2):120.e1–5. https://doi.org/10.1016/j.ajog.2010.07.010

40. Donders GGG, Grinceviciene S, Ruban K, Bellen G. Vaginal pH and microbiota during fluconazole maintenance treatment for recurrent vulvovaginal candidosis (RVVC). Diagn Microbiol Infect Dis. 2020 Jun;97(2):115024. https://doi.org/doi:10.1016/j.diagmicrobio.2020.115024

41. Alexiades MR. Fractional Co2 laser treatment of the vulva and vagina and the effect of postmenopausal duration on efficacy. Lasers Surg Med. 2021 Feb;53(2):185-98. https://doi.org/10.1002/lsm.23247

42. Carter J, Baser RE, Goldfrank DJ, Seidel B, Milli L, Stabile C, et al. A single-arm, prospective trial investigating the effectiveness of a non-hormonal vaginal moisturizer containing hyaluronic acid in postmenopausal cancer survivors. Support Care Cancer. 2021 Jan;29(1):311-22. https://doi.org/10.1007/s00520-020-05472-3

43. De Seta F, Caruso S, Di Lorenzo G, Romano F, Mirandola M, Nappi RE. Efficacy and safety of a new vaginal gel for the treatment of symptoms associated with vulvovaginal atrophy in postmenopausal women: a double-blind randomized placebo-controlled study. Maturitas. 2021 May;147:34-40. https://doi.org/10.1016/j.maturitas.2021.03.002

44. Melo MO, Campos PMBGM. Função de barreira da pele e pH cutâneo. Cosmetics & Toiletries. 2016 Mai-Jun;28:34-8.

45. Blaak J, Staib P. The relation of pH and skin cleansing. Curr Probl Dermatol. 2018;54:132-42. https://doi.org/10.1159/000489527

46. Lambers H, Piessens S, Bloem A, Pronk H, Finkel P. Natural skin surface pH is on average below 5, which is beneficial for its resident flora. Int J Cosmet Sci. 2006 Oct;28(5):359-70. https://doi.org/10.1111/j.1467-2494.2006.00344.x